

# **MEANDER STATISTICS TOOLBOX (MStaT v1.1) – USER’S MANUAL**



## Introduction

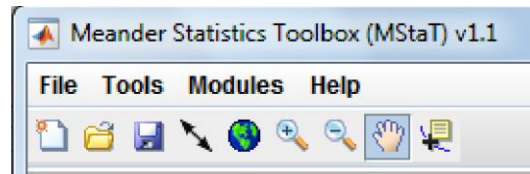
The Meander Statistics Toolbox (MStaT) is a standalone software that allows the execution of three independent modules to obtain geometric variables that allow the integral characterization of a meandering channel. Therefore MStaT allows to obtain a large number of geometric variables of the meandering channels (arc-wavelet, sinuosity, curvature, amplitude, inflection point, among others) and perform a Wavelet Transform type analysis and thus obtain a power spectrum. This toolbox represents the efficient performance of multi-disciplinary projects such as restoring channelized streams to more natural, stable conditions or reducing the urbanization effect in waterways engineering. Different areas can use this toolbox for the purpose each one. For example, the scientific utilities are: 1) analyzing the interrelationship between meanders and planform; 2) the influence of sinuosity on the surface and groundwater interrelationship, 3) impact of channelized in the meandering river. The practical results purposes: 1) the design of civil infrastructure protection; or 2) river restoration. Also MStaT allows calculate the migration of a period, and analyzes the migration signature (Migration Module). Finally MStaT has a Confluence Module that allow calculate the influence due the presence of the tributary channel on the main channel.

## SETUP

- Download and install MATLAB Runtime version 9.0 (R2015b) it can be downloaded from <http://www.mathworks.com/products/compiler/mcr/index.html> (You'll need administrator rights to run MCRInstaller).
- Download the MStaT latest version, open the folder called for redistribution and open the application (.exe archive).
- Notice that the compiled version available is compatible only with Windows x64.
- It is worth mentioning that it is possible to download the MStaT source codes of <https://github.com/ldominguezruben/mstat>.

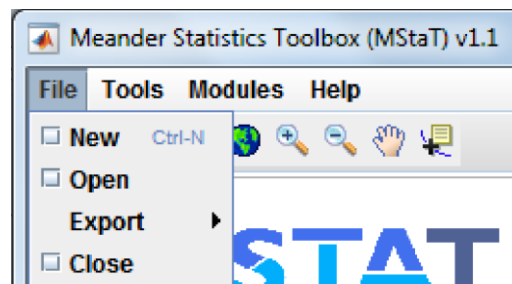
### 1. MStaT MENUBAR

This image shows the menu bar of the MStaT code. The new project, file reading, file saving, measurement ruler, zoom in zoom out, pan and data cursor tools are highlighted.



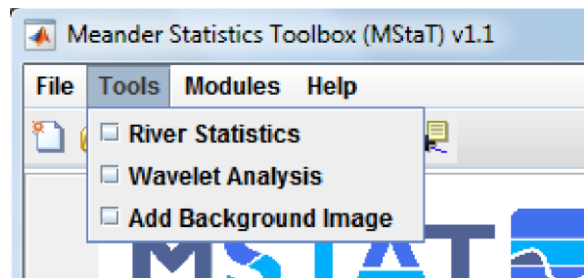
**Figure 1.-** Menu toolbar of MStaT.

File menu of MStaT offers the possibility of a simple reading as well as the generation of new files, the export and the possibility of closing the environment.



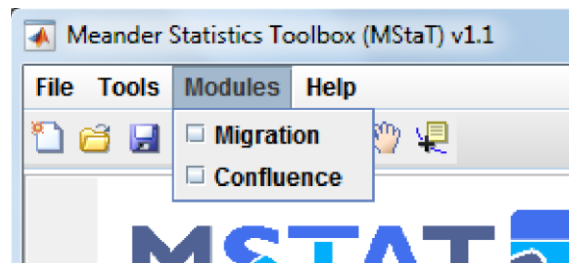
**Figure 2.-** Menu toolbar, File of MStaT.

The file menu allows introducing the information necessary to obtain the meanders parameters and to export the results of the processing. The inputs can be a .txt file, xlsx. Excel file, or a .kml file (Google Earth®).



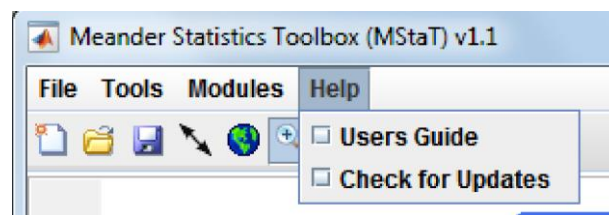
**Figure 3.-** Menu toolbar, Tools of MStaT.

The tools menu show the advanced results, as wavelet analysis and statistics of each meander (sinuosity, amplitude, arc-wavelength, and wavelength).



**Figure 4.-** Menu toolbar, Modules of MStaT.

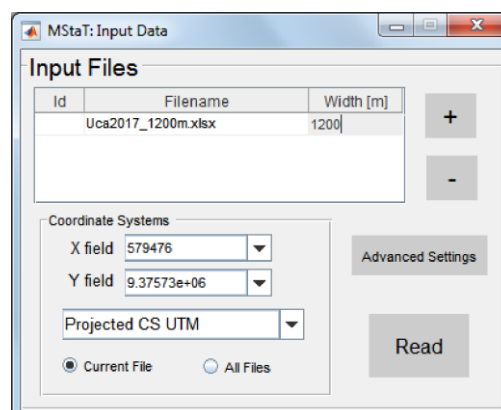
The help allows, on the one hand, to access the MStaT manual and the blog with the latest software updates (<https://meanderstatistics.blogspot.com/>).



**Figure 5.-** Menu toolbar, Help of MStaT.

## 2. Open file

- Click on File menu and Open
- Select the file in the formats .txt, .xls, .xlsx, .kml.
- Then you must enter the average width of the section under study. This input panel allows you to add or delete files.



**Figure 6.-** Input Data of MStaT.

- - In each file (once the average width has been entered) you can optionally access the Advanced Settings.

- This last panel allows modifying the width, the decomposition level 8 by default ( $j = 5$ ). Additionally you can modify the polynomial order of decomposition the smoothing, the Windows, and reach points. All this can be previewed and saved later.
- Once the previous parameters have been modified, it is possible to read the file.

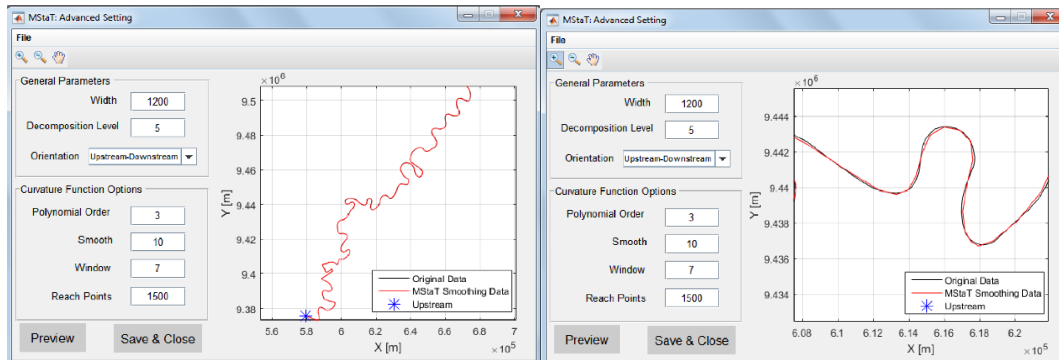


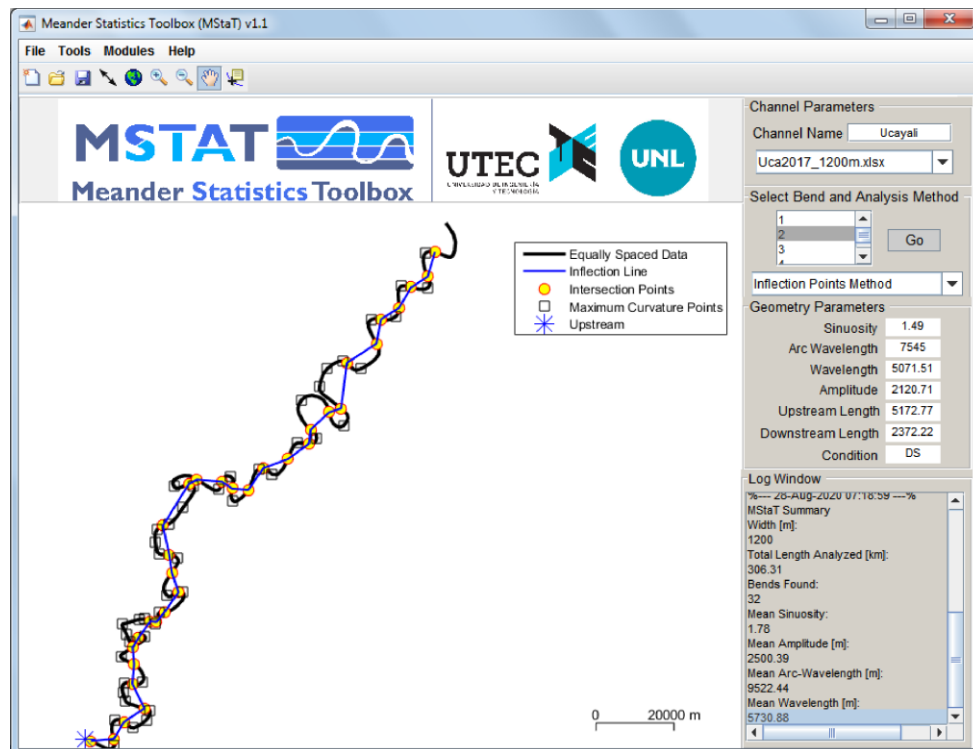
Figure 7.- Advanced setting of MStaT.

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

### 3 Results and Visualization

#### 3.1 Meandering Morphometric Module

MStaT will show the river with its inflection points and the valley centerline. In the upper zone, there is a chart with the information of every meander. We can select the number of the meander we want to see and press “Go” to show the information.



**Figure 8.-** Meandering Morphometrics Module of MStat.

The parameters that are considered are:

- Sinuosity
- Arc-wavelength
- Wavelength
- Amplitude
- Upstream Length
- Downstream Length

### **3.1.1 Tools**

In the tool menu, there are two Tools options: “River Statistics” and “Wavelet Analysis”.

#### **3.1.1.1 River Statistics**

This option generates a table with the information of each meander and then can be exported in Excel® file.

MStaT: Statistic Variables								
Export								
	Bend ID	Sinuosity	Arc Wavelength [m]	Wavelength [m]	Amplitude [m]	Condition	Upstream 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 first option shows four graphics related to the wavelet analysis.

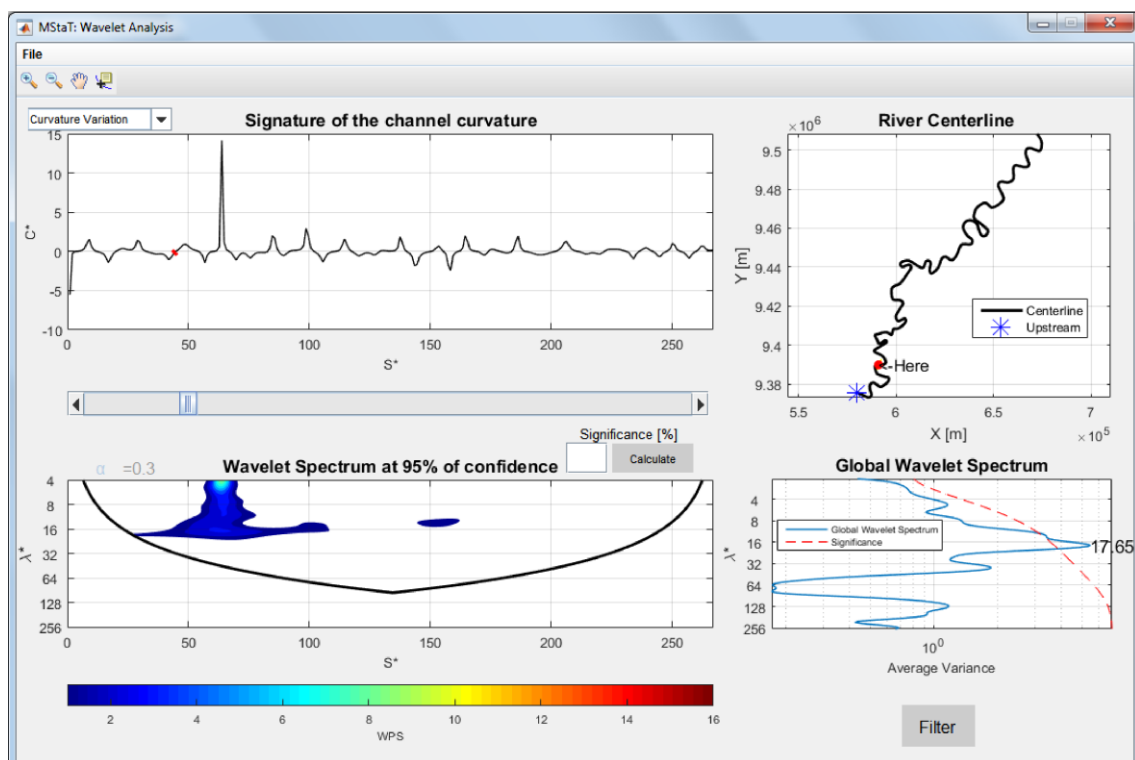
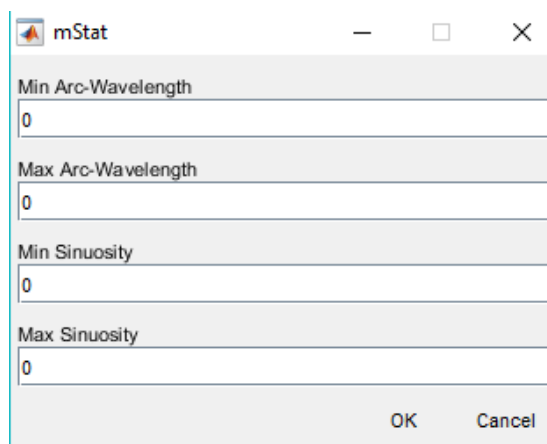


Figure 10.- Wavelet Analysis of Meandering Morphometrics Module MStaT.

In the previous Figure 10 can filter the wavelet analysis using the sinuosity and arc-wavelength.

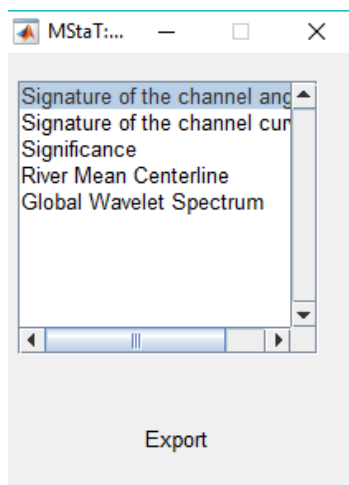
- a) **Filter:** This option allows selecting the values or range of values that the user wants to see specifically. It can be filtered by writing the min or max value of Arc-Wavelength or Sinuosity.



**Figure 11.-** Filter of Wavelet Analysis of Meandering Morphometrics Module MStaT.

- b) **Export Figures:** In this option, the user can export the figures created from the wavelet analysis.

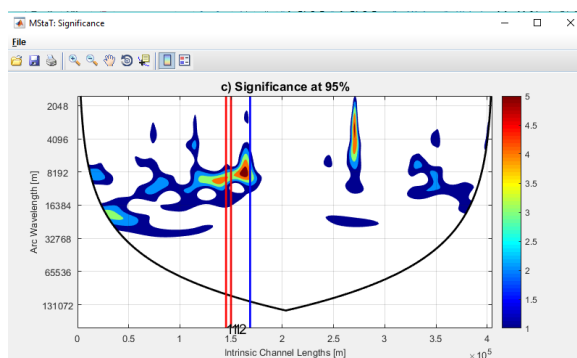
First, the user have to select the graphic to export.



**Figure 12.-** Print and export Wavelet Analysis of Meandering Morphometric Module MStaT.

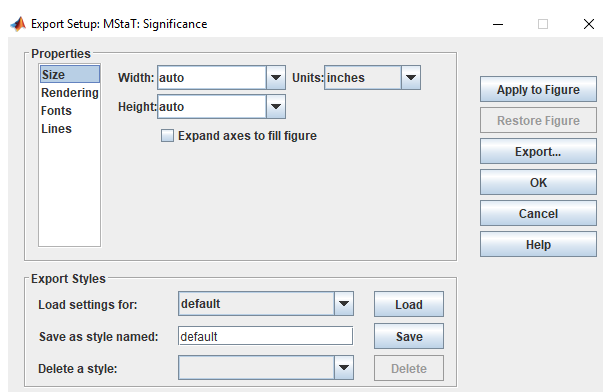


A new screen will appear. In this screen the user can select the items that will appear in the graphic (colorbar and legend).



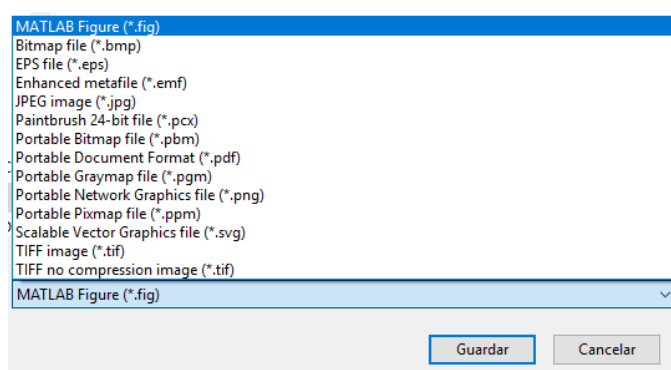
**Figure 13.-** Wavelet plot and export Wavelet Analysis of Meandering Morphometric Module MStaT.

The option Export Setup, in the file menu, allows to change some preferences to export the graphic (size, rendering, fonts, lines). Then press Export (Figure14).



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

In the next screen, the user needs to select the type of file to export. The next options can be selected:



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

### 3.1.1.3 Background image options

The background image must be in .tiff format, this means that it must be georeferenced. See the following link for more information on its pre-processing (<https://mdl.library.utoronto.ca/technology/tutorials/how-georeference-images-arcgis>).

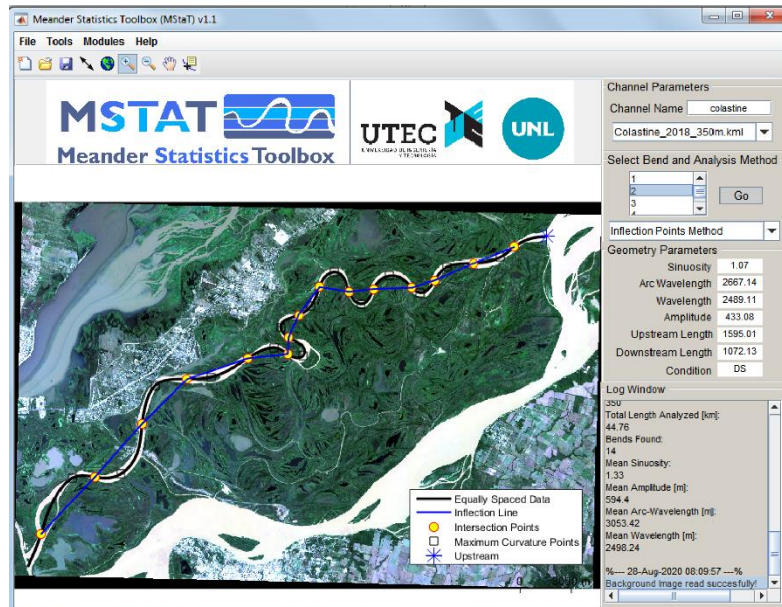


Figure 16.- Background image of Meandering Morphometrics Module MStat.

#### 3.1.1.4 Export output files

Finally, to export the information from the processing, MStat give the option to export as:

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

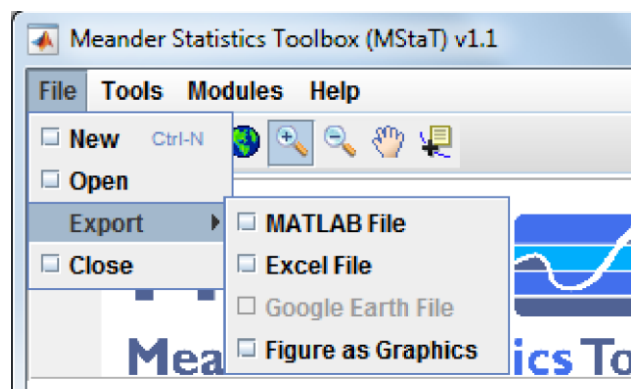


Figure 17.- Export Tools of Meandering Morphometrics Module MStat.

### 3.2 Migration Module

*Meander Statistics Toolbox (MStat)*

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.

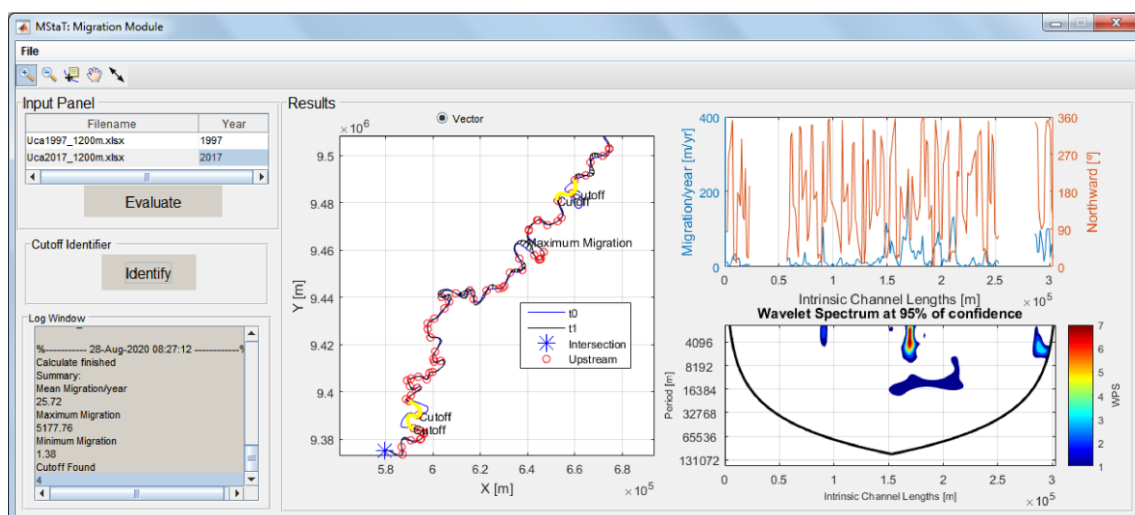
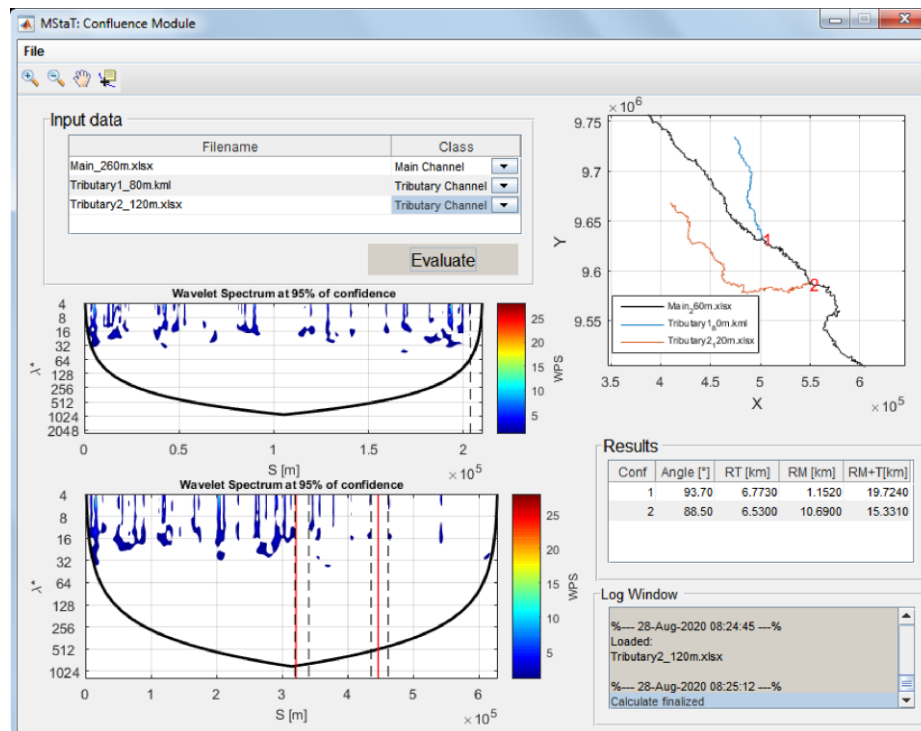


Figure 18.- Migration Module MStaT.

### 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.