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viStaMPS – a Collaborative Project for StaMPS-MTI Results Interpretation

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Abstract

In the last decade, SAR interferometry techniques, especially those that use time series analysis experienced a strong development in both, methodologies and applications, becoming an operational tool for deformation monitoring. The emergence of a growing number of SAR dedicated missions combined with the increasing interest from academics, but also private research groups, reflected in the number of available software packages developed with interferometric analysis purposes, were the major responsible for the InSAR/MTI achievements occurred over the past few years.

Many free-of-charge (freeware or open-source) and commercial software packages exist. Due to its proven reliability and freeware distribution among the scientific community, Stanford Method for Persistent Scatterers/Multi-Temporal Interferometry (StaMPS/MTI) implementation, is widely used for ground deformation monitoring. This paper presents viStaMPS v1.2, a collaborative scientific project that appeared with three major purposes: (1) facilitate the usage by users unfamiliar with the specificities of the programming language that supports StaMPS; (2) implement several visualization tasks not available in the StaMPS standard approach requiring that each user to develop its own code for visualization and interpretation purposes and (3) create a collaborative research project, continually under development counting on the dynamism of its users to improve and/or add new features.

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1. Introduction

This paper presents Visual StaMPS (viStaMPS) [1], which is made available for non-commercial applications only and can be downloaded from <http://vistamps.utad.pt>.

Due to its proven reliability and freeware distribution among the scientific community, Stanford Method for Persistent Scatterers (StaMPS) [2, 3, 4] InSAR implementation which is based on the processing of multi-temporal SAR data, is widely used for ground deformation monitoring. However, some issues can make results interpretation an arduous task. StaMPS supports data processing based on command prompt, which increases the difficulty of usage by users unfamiliar with the specificities of the programming language that implements StaMPS. Moreover, several visualization tasks are not implemented in the standard approach requiring that each user develop its own code for visualization and interpretation purposes.

viStaMPS is a collaborative project, materialized into a visual application developed to enhance the visualization, manipulation and exportation of StaMPS results. The programmed application is developed in Matlab® through the Graphical User Interface (GUI) and no coding is required for running it, which avoids any programming language knowledge for standard uses. This tool integrates fully new features together with various scripts from StaMPS, allowing the generation of the desired plots/maps in a user-friendly interface. It is done by simply clicking some buttons or changing some parameters located in visual panels, instead of input commands in a prompt. Moreover, since it is written in Matlab, it gives the users the opportunity to access the data very easily and perform their own modifications.

viStaMPS v1.1.1 [5], currently available, is being used by more than 300 researchers worldwide, it is in constant development and includes, at this stage, an extensive range of new features that will be depicted in more detail along this paper. In the next phase, viStaMPS (v2.0) functionalities, now only available for PS results, will also be implemented to Small Baseline (SB) results.

In order to maintain full compatibility with StaMPS package, which is constantly suffering improvements, both groups collaborate closely.

Figure 1 presents the viStaMPS main window, which is divided in four main areas: A (Data Processing), B (Data Visualization/Manipulation) and (output). Each operation can be accessed through different buttons and options located on the application panels. Depending on the selections made, buttons and/or parameters can toggle between active/inactive states.

In the next sections viStaMPS main features will be presented and described in more detail.

2. Data processing

viStaMPS Data Processing section is composed by two buttons (Setup and Data Display). As shown in Figure 1, the first time viStaMPS is started, most of the options show inactive states. This is because the work folder is not yet defined.

Before starting, it is mandatory to setup the project by pressing the Setup button. This operation will originate the window presented in Figure 2a. The Scale Factor is directly related to the multilook factor, by default is set to 1, corresponding to a multilook [1 5] and the Distance parameter, that is used in the 3D visualization, is set to 5 (see later its meaning); Scale Factor parameter plays a key role, since, depending on the size of the area and the computer memory, this value may be reduced. Generally, crops containing < 5 million SLC pixels are OK (lower values require less processing time).

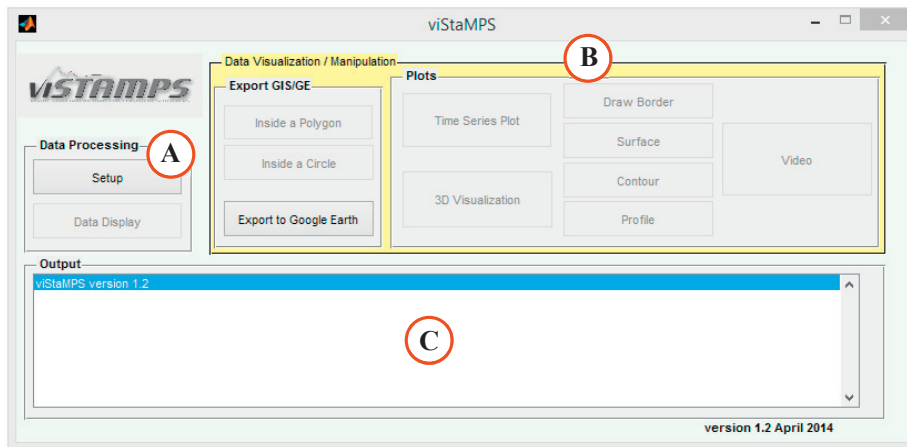


Fig. 1. viStaMPS main window.

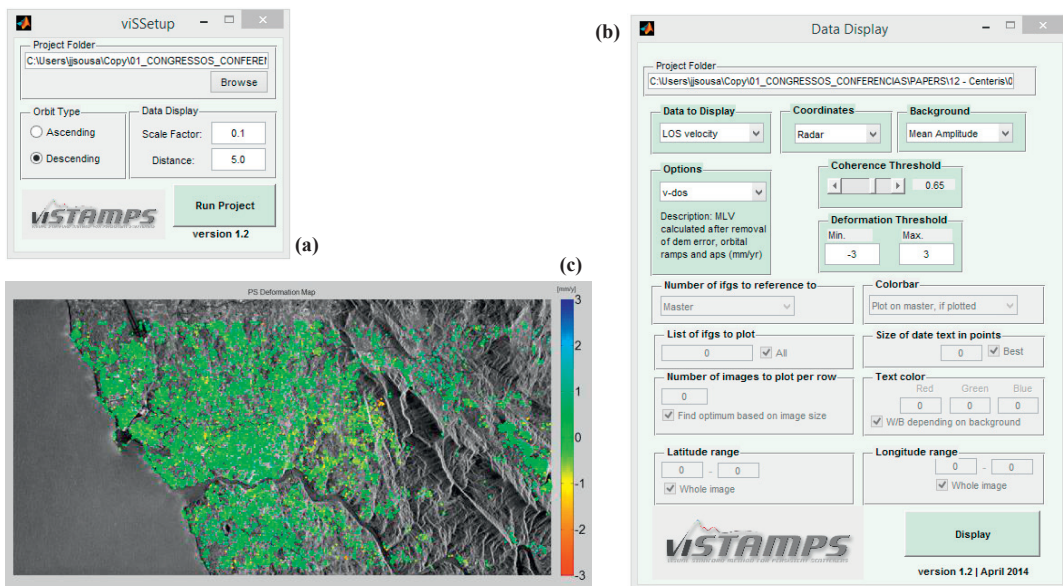


Fig. 2. viStaMPS Data Processing: (a) Setup window; (b) Data Display window and available options for Data to Display, Background and Options sections; (c) LOS Average velocity measured over the time period of satellite imagery analyzed for each ground measurement point identified. Color scale is calculated according to the maximum and minimum data values. The mean amplitude image is used as background.

Main parameters used are also shown.

After defining the project folder and confirm some needed parameters, Data Display button become active. Pressing this button will originate the window presented in Figure 2b which is divided in two main parts. The upper part contains the parameterizations related to LOS velocity data display both in radar and geographic coordinates, allowing: (1) the selection of different backgrounds, value types (the effects of the following estimations can be removed from the displayed results: atmosphere and orbit error due to the master, atmosphere and orbit error due to the slave, phase ramps, and DEM error); (2) filtering the points according to the coherence threshold selected; and

(3) the definition of the minimum and maximum deformation rates to be displayed (by default, min and max values of the whole dataset are used).

After selection of the desired options, the `Display` button will show the deformation map, as shown in [Figure 2c](#). StaMPS plots all the points detected regardless of noise values or the deformation rates while viStaMPS includes the possibility of filtering the results according to deformation and coherence thresholds through a slide bar.

If the `Data Display` is set to `Wrapped phase` or `Unwrapped phase` the lower section of `Data Display` window becomes active. All the parameters available to run StaMPS `ps_plot.m` script (see StaMPS manual for more details) can be accessed from here.

3. Data Visualization and manipulation

For most users, this is probably the most attractive section of viStaMPS, together with deformation and coherence threshold features, since it includes several features allowing data visualization and manipulation using different methodologies. In the next subsection more details on this will be provided.

This section of viStaMPS v1.2 presents significant improvements compared to the previous version. It allows video generation with different scenarios at the processed area throughout the whole time series period but also projecting the deformation/consequences in the future. Only the new functionalities are explained in detail, since the remaining were already implemented in the previous version.

3.1. Export GIS/GE

viStaMPS allows the exportation of part (drawing a polygonal or a circular area) or the whole processed area by simply clicking a button. Detailed geocoded 2D or 3D point information can be exported to Geographical Information System (GIS) applications allowing the creation of maps of the different data fields (average velocity, cumulative displacement, etc.).

By pressing `Export to Google Earth` button, we will be asked to browse for a file to be exported to GE ‘.kml’ file. Choose, consecutively, one of the files exported using `Inside a Polygon` or `Inside a Circle` to generate the corresponding GE file and the desired (corresponding) colorbar image.

3.2. Plots

Time Series Plot

Time series plot helps in the analysis and interpretation of results, since it describes the evolution of displacement over the entire analyzed period. In viStaMPS, time series plots can be visualized by simply picking a PS from the deformation map. The resulting plots will reflect the viStaMPS parameters used for plotting the deformation map. In this new version of viStaMPS it is possible to fit the time series to distinct deformation regimes, depending on the causes and type of the deformation and also restrict the time series range. [Figure 3](#) shows the new time series plots interface and its functionalities.

3D Visualization

The reliability of the interpretation of interferometric data can be increased by an appropriated 3D-visualization of the data. The result from StaMPS analysis consists on discrete ground measurement points, each of which has a temporal displacement. Data can be presented as single points on a background map or as interpolated points creating, for instance, a 3D perspective visualization of the deformation surfaces.

Draw Border, Surface, Contour and Profile

`Draw Border` button become active when a map deformation window is open, allowing the user to draw one or multiple borders that will be used to create surfaces, contours and profiles on the defined regions. [Figure 4](#) presents the use of all these features.

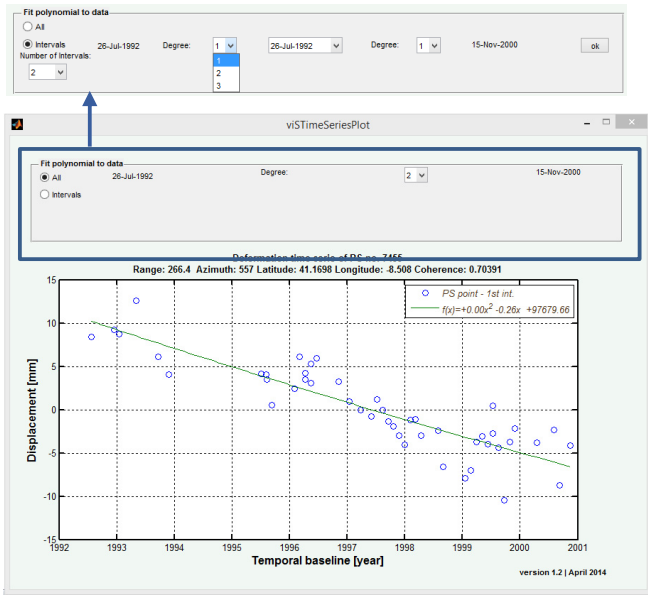


Fig. 3. The new time series plot interface allowing choosing different deformation regimes that fit specific time range.

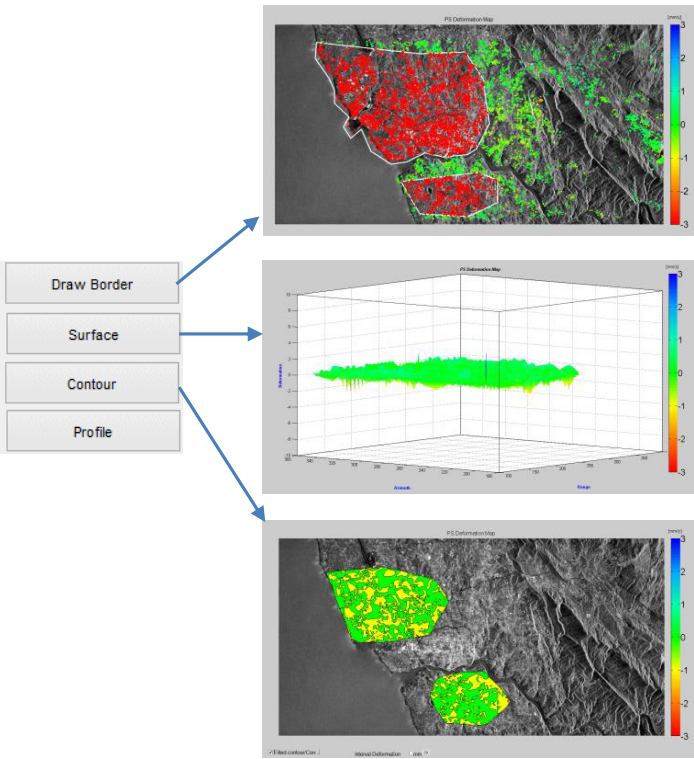


Fig. 4. Defining borders and creating surfaces and contour plots.

Video

Finally, using viStaMPS v1.2 it is also possible to generate deformation videos covering the whole or part of the SAR time series. **Figure 5** illustrates this new feature.

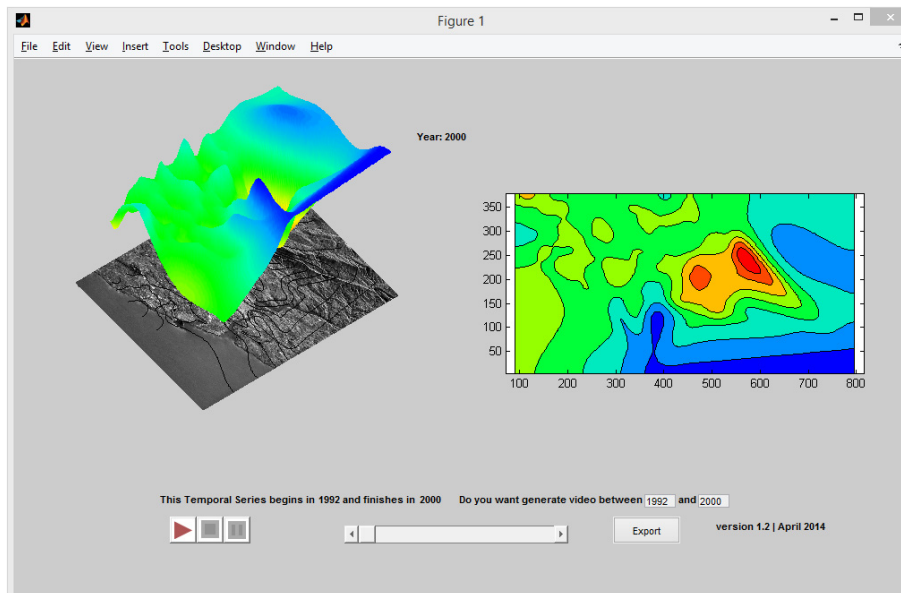


Fig. 5. Video generation using viStaMPS. Using this interface it is also possible to project deformation scenarios by introducing a desired future date.

4. Conclusion and Future Work

Being a research tool, viStaMPS is continually under development. Future development of viStaMPS includes the improvement of code/interface and the accomplishment of usability tests in order to help the navigation experience. In the next few months, PS+SB visualization features will be included (next version). viStaMPS team would like to convert, also in a near future, the full StaMPS processing chain into a visual application and include new processing techniques in order to increase the density of PSs (the Quasi Persistent Scatterers – QPS – algorithm [6] will be studied and implemented).

Our final goal is to provide viStaMPS with different options for combining long series of data, and give the user the opportunity to choose which set of interferograms to process and with which techniques (PS, SB, QPS or combinations). Currently, viStaMPS is only a module dedicated to PS data visualization and exportation.

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