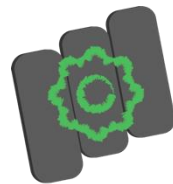




Sentinel-1 SAR Interferometry Processor

The Sentinel-1 interferometry processor is developed by the Radar Imaging Geodesy Group at Peking University ([https:// sarimggeodesy.github.io/](https://sarimggeodesy.github.io/)). The software package is designed for large-scale InSAR processing with Sentinel-1 TOPS images, which includes 4 modules:



Path Manager Tool
PathManager.exe



InSAR Processing Tool
InSARProc.exe



Interferometric
Configuration & Mosaic Tool
(ImageMosaic.exe)



Time-series InSAR Analysis Tool
(FormatConversion.exe)

Key features include.

1. The processing is based on Sentinel-1's burst configuration, allowing for flexible processing strategy. The mosaic of burst interferogram is unlimited. The software can not only process single-burst interferogram, but also mosaic **any number of frames** to form an interferogram spanning thousands of kilometers.
2. The software is fully parallelized based on multi-thread algorithms. The processing time for producing one full-frame geocoded interferogram (90m resolution) is only **5 minutes and 5 seconds** (test environment: Thinkpad Laptop, Intel(R) 6-core i7-8850H CPU @2.60GHz, 32 GB RAM, SSD hard drive).
3. The entire process is **fully automatized**. According to the application requirements, users only need to set the multilook factors, filter parameters, baseline thresholds for interferometric configuration and a few parameters regarding to the area of interest. After that, the data processing can be done without human interaction.
4. The software uses a de-reference SLC storage strategy, which allows for less storage space occupation, fast and flexible processing. Users can **quickly generate any interferograms based on given baseline configuration**. After the burst-based processing, the processing time for producing a geocoded full-frame interferogram (90 meters) is less than one minute.
5. Interferograms are stored in geotiff format, and the radar parameter files are stored in text files. Users can choose any area in the map interface to export the result to StaMPS format for time-series InSAR analysis.
6. Windows **graphical user interface**, easy to operate, easy to use, no professional training is required to generate interferograms for various applications.

Processing Manual

1, Path Manager Tool (PathManager.exe)

The path management tool includes: New project creation, Sentinel-1 Data Decompression, Data coverage view, Orbit data download, DEM download and automatic stitching, Primary-Secondary image selection, Baseline calculation, etc.

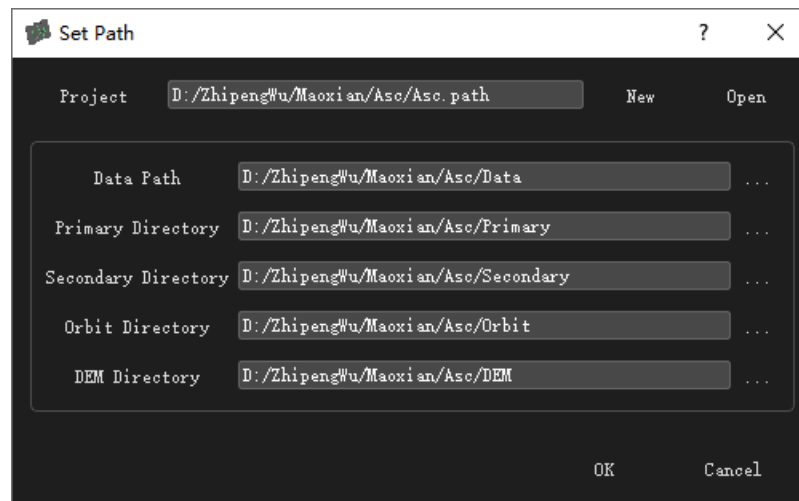


Fig. 1 Path Manager Tool Interface-Set Path

The path management tool allows users to create or select a project file, set the corresponding file paths. The data coverage is displaced to the left and a temporal-special baseline map is displaced to the right.

1) Create or open the project file to specify the appropriate folder.

- Data Path: Creates a folder to hold all compressed or decompressed data files to be processed. Note that all images must be from the same Path (track), but can be from any number of frames. The initial name of the data files cannot be changed.
- Primary Directory: Creates an empty folder where the primary image will be placed.
- Secondary Directory: Creates an empty folder where all secondary images will be placed later.
- Orbit Directory: Specifies the folder that contains the orbit data. It can be empty where the software can download the orbit data automatically.
- DEM Directory: Specifies the folder that contains the DEM covering all the Sentinel-1 data coverage (geotiff format). It can be an empty folder where the software can download the

DEM.

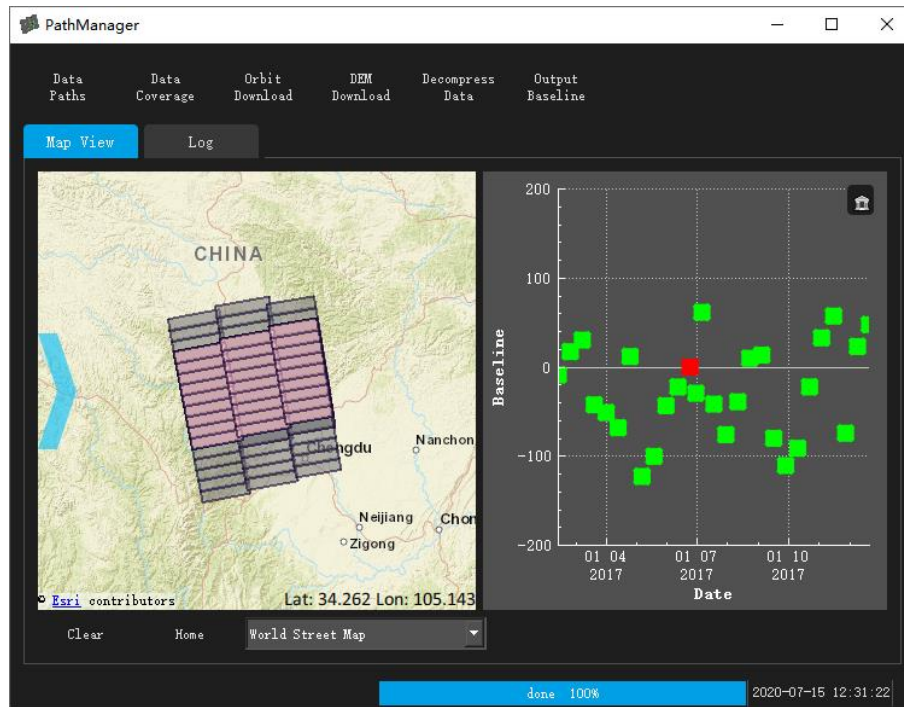


Fig. 2 Path Manager Tool User Interface

2) Click the "Data Coverage", the software can display the image coverage and the baseline distribution on the right side. Set the primary image by right-clicking the box you want to set for. Double-click the box and the coverage of that image will be shown in pink on the left. If there are multiple Frames, the number in the box represents the number of frames in the same Path.

3) After selecting the primary image, click "Decompress Data", the software will perform the decompression and move the primary and secondary images to their corresponding folders. Do not close the software while moving and decompressing, otherwise the next process will report an error.

4) Click "Orbit Download" to download the precision orbit data files required for interferometric processing.

5) Click "DEM Download", the software will determine the coverage of the primary image, and download the corresponding DEM from internet, and complete the automatic stitching.

6) Click "Output Baseline" to save the baseline data as a text file.

The "Log" tab displays the process and status of the processing.

2, InSAR Processing Tool (InSARProc.exe)

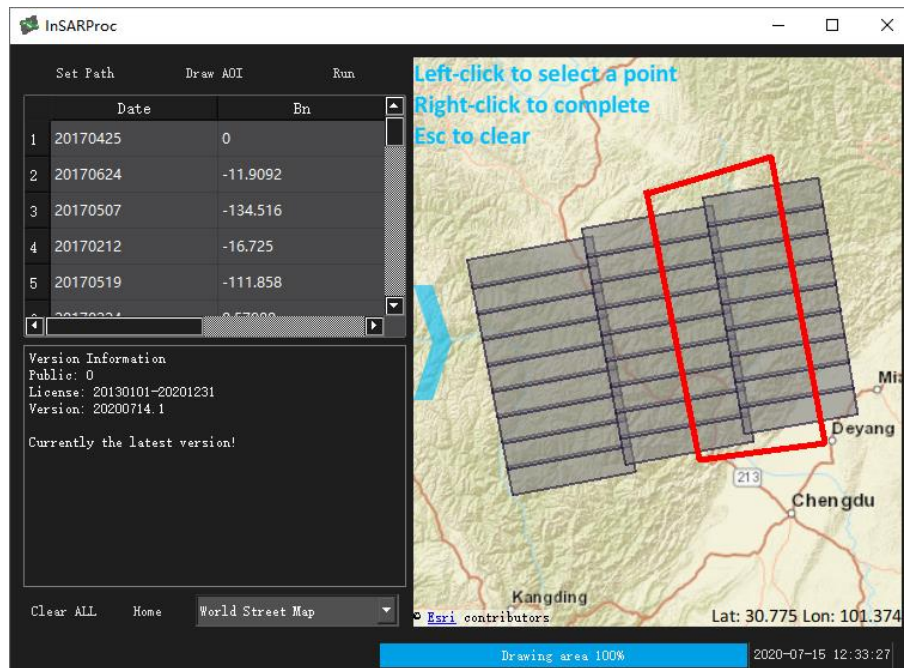


Fig. 3 InSAR processing Tool User Interface

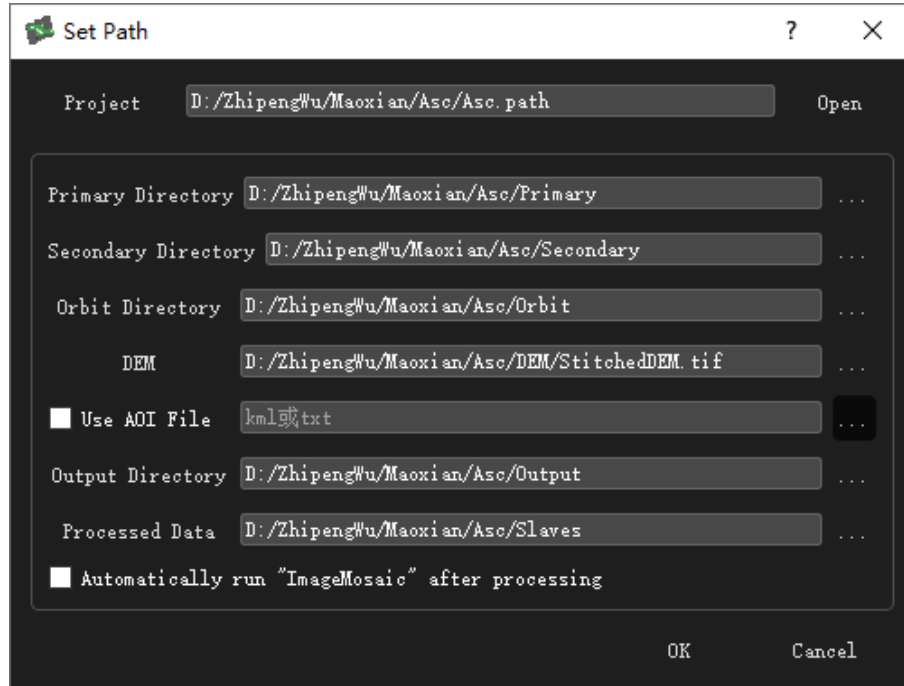


Fig. 4 InSAR processing Tool User Interface - Set Path

The InSAR processing Tool includes basic interferometry functions such as image coregistration, AOI

selection, differential interferometry processing, coherence calculation, etc. The main interface displays a list of data on the left side, and displaces images and maps on the right.

1) Click the "Set Path" button to set the resulting data path.

- Out Directory: Specifies the folder in which to store SAR images with the reference phase removed after coregistration.
- Processed Data: Specifies the folder where the processed images are stored. After processing, files in this folder can be deleted when the storage space is tight.
- AOI: Either a kml or a text file (polygon corner point latitude and longitude coordinates) can be specified as the AOI file. If AOI is not selected or drawn in the interface, the software will process all bursts of the primary image by default.
- If "Automatically run ImageMosaic.exe after" is checked, the software will automatically run ImageMosaic.exe for burst-mosaic processing. The parameters used are those in the *.path file in the current project directory, you can use a text editor to open the *. path file to modify them before you start processing (see the description of the burst mosaic tool).

2) If users do not specify AOI in the Set Path table, the software supports manual selection of AOI. Press the space bar or click the button "Draw AOI" to draw the area of interest manually, the software will select the burst according to AOI to be processed for subsequent processing.

3) After setting up, click the "Run" button for coregistration and interferometry. This process is built up on a burst-based processing strategy. The output are differential interferograms and coherence maps for each burst with respect to the primary image in radar coordinates, stored in the output specified folder.

3, Interferometric Configuration and Mosaic Tool (ImageMosaic.exe)

Interferometric Configuration and Mosaic Tool includes differential interferogram generation, interferogram configuration editing, interferogram mosaic, geocoding, phase unwrapping, stacking, etc. The output products include differential interferograms, filtered interferogram, coherence maps, amplitude maps in both radar and geocoded coordinates. The left side of the interface is the list of interferometry pairs, and the right side displays the map, image in radar coordinate, spatial-temporal baselines views based on their corresponding tables on the top.

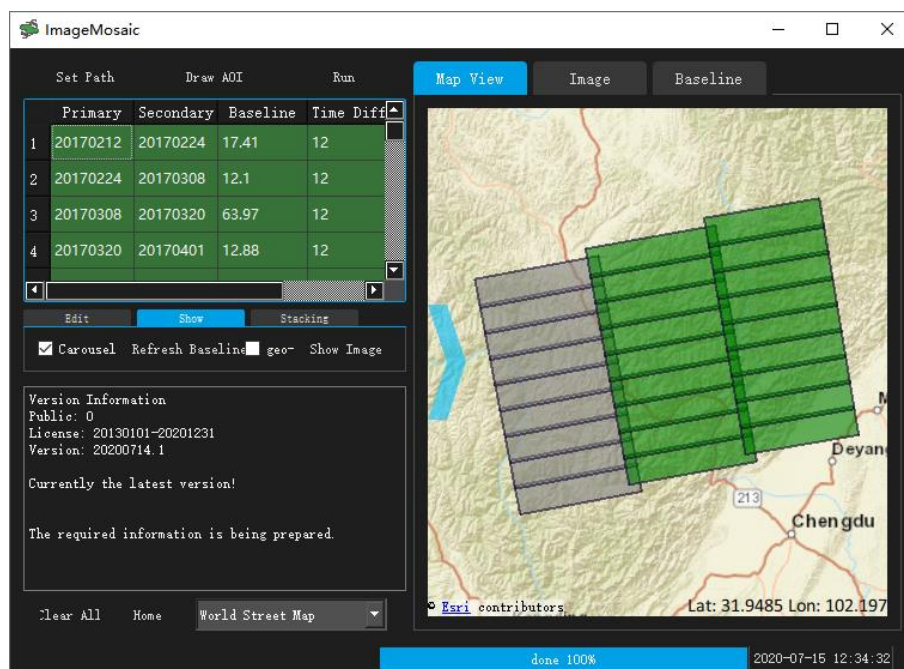


Fig. 5 Interferometric Configuration and Mosaic Tool User Interface – Data Processing

1) Click the "Set Path" button to set the processing result path and processing parameters.

- Out Interf Folder: Creates an empty folder to store the mosaiced interferograms.
- AOI: Either a kml or a text file (polygon corner point latitude and longitude coordinates) can be specified as the AOI file. If AOI is not selected or drawn in the interface, the software will mosaic all bursts of the main image by default.
- Check Interf to generates the interferogram.
- Check MeanAMP to generate the average magnitude map.
- Check MeanCoh to generate the average coherence map.

- Check geocode to do geocoding, the resolution is determined by the given DEM.
- Multilook: multilook factors, Multi_rg (in range), Multi_az (in azimuth).
- Goldstein interferogram filtering: The Goldstein filtering parameter setting.
- Tabs: “Baseline range to specify the intf pair:” determines the interferometric pairs to be processed according to the temporal baseline range. Users can also create a text file in the format "Primary Image Date Secondary Image Date" (yyyymmdd yyyymmdd) to specify the interferometric pairs to be processed.
- Other parameters specified in the previous processing, stored in the project file *.path, and can be modified when necessary.

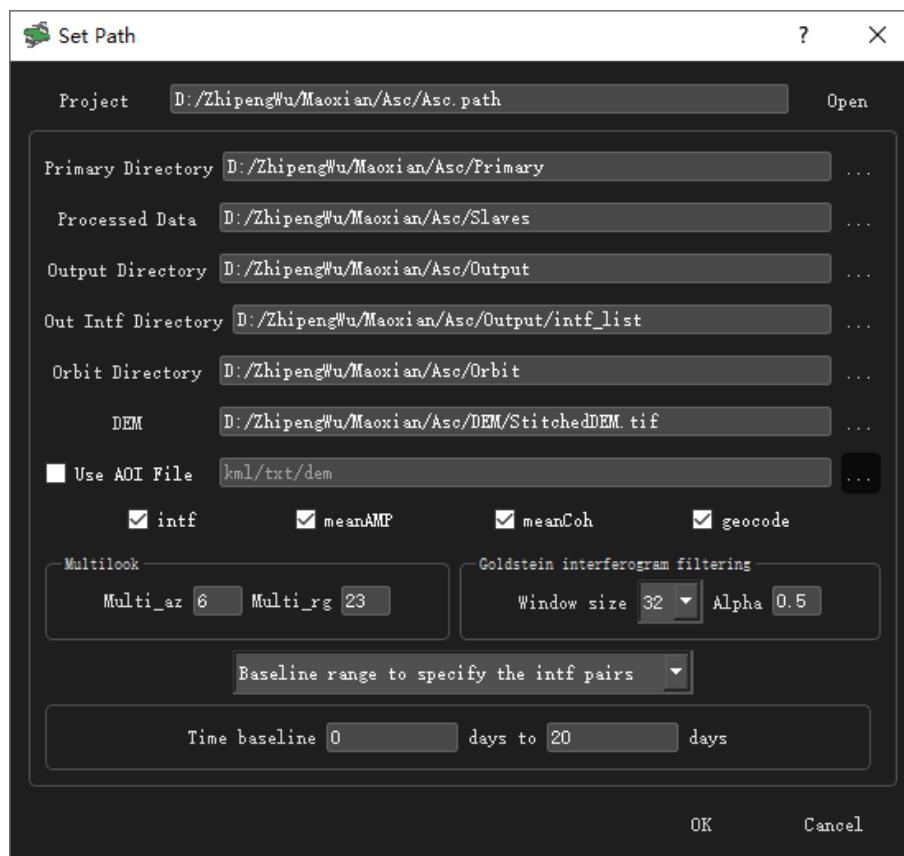


Fig. 6 Interferometric Configuration and Mosaic Tool User Interface – Set Path

2) Press the space bar or click the button "Draw AOI" to manually draw the area of interest, the software will select the burst according to the AOI to mosaic.



Fig. 7 Interferometric Configuration and Mosaic Tool User Interface – Baseline

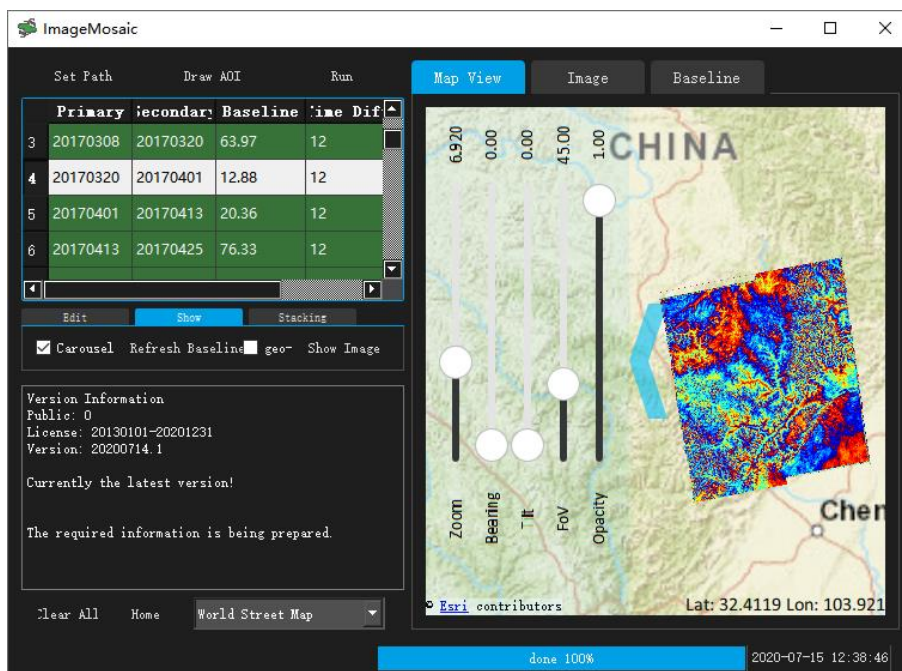


Fig. 8 Interferometric Configuration and Mosaic Tool User Interface – Geocoded interferogram

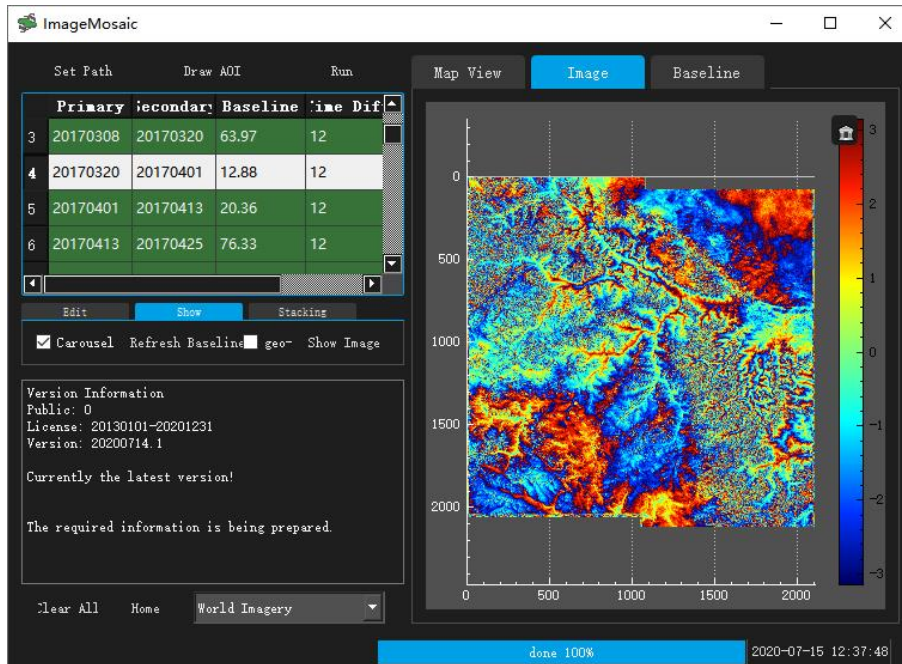


Fig. 9 Interferometric Configuration and Mosaic Tool User Interface -Interferogram in radar coordinate

3) Interferometric configuration: To the table on the top left, users can sort image pairs by clicking on the table header. Image pairs can be selected through the baseline view on the right, or the table on the left. During the selection, users can press and hold "Ctrl" or "Shift" for multiple selection. Click "edit" tab under the table to delete and modify any image pair. The interferometry and mosaic processing are based on the image pairs displayed in the table on the left.

4) After determining the AOI and interferometric configuration, click the "Run" button on the top to start the interferogram mosaic and geocoding.

5) When the processing is complete, click the "Map View" tab to display the results of the image superimposed on different map. Users can click the blue arrow to adjust the view, through the "Opacity" slide button to set the transparency. Users can also select different the map styles from the "World Street Map" drop-down list in the main interface. The "Carousel" check box to specify whether to rotationally display the images.

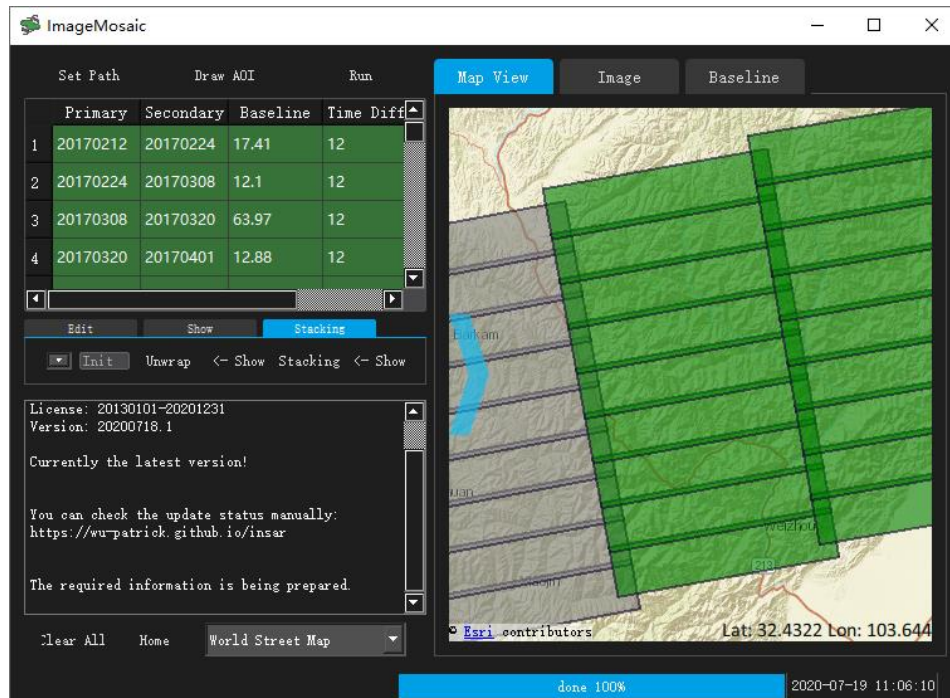


Fig. 10 Interferometric Configuration and Mosaic Tool User Interface – Phase unwrapping and Stacking

6) Switch the tab in the main interface to "Stacking" for phase unwrapping and stacking. Phase unwinding is performed using the Statistical-cost, Network-flow Algorithm for Phase Unwrapping (SNAPHU) Toolkit. During the phase unwrapping, the software supports two masking methods: specifying coherence threshold or using an existing mask file (manually generated masks should be the same size as the mosaiced interferogram, and should be put in the folder of the corresponding interferogram).

7) Switch the table in the main interface to "Image" can display interferograms in geocoded or radar coordinates. The switch between the two by "Show" button with "geo->" checked. The default color map is the same as the "Map View" tab displays, you can scroll or drag to adjust the color mapping, right-click will restore the default setting.

4, Time-series InSAR analysis Tool (FormatConversion.exe)

The time-series InSAR analysis module is still under development. The software now supports exporting for the analysis using the Stanford Method for Persistent Scatterers (StaMPS).

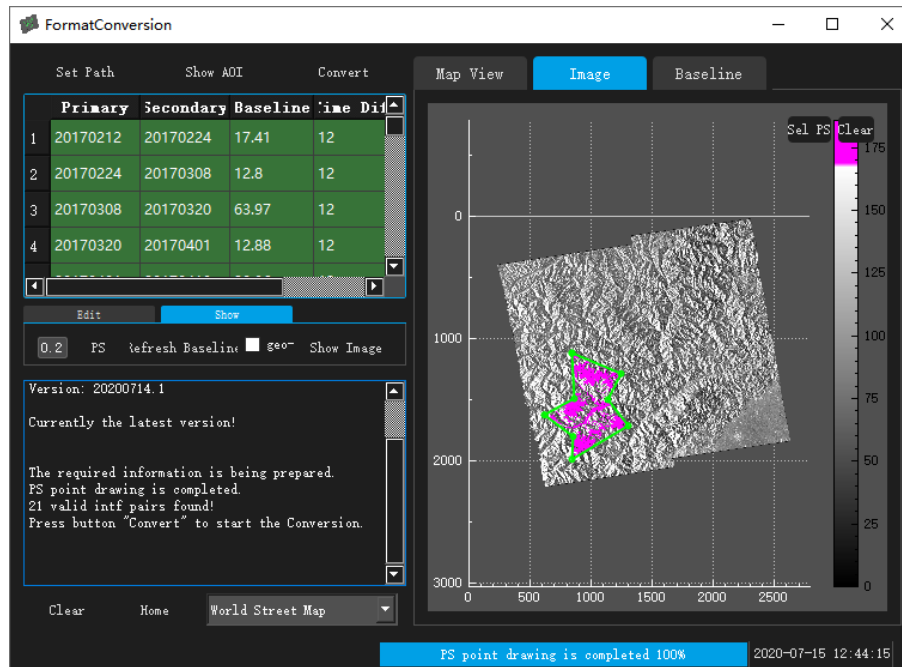


Fig. 11 Time-series InSAR analysis Interface – Export for StaMPS

1) Click the "Set Path" button to set the result data path and processing parameters, which are the same as those in the *.path file. If necessary, users can modify these parameters by editing the *.path file. Same as the **Interferometric Configuration and Mosaic Tool**, the exported interferometric pairs can be reselected either on the table or by a specific file.

2) Click "Show AOI" to display the image coverage based on pre-assigned AOI.

3) Set the coherence threshold on the left side of "PS" and click "PS" to display the pixel with higher coherence values than the threshold. Click on the button "Sel PS" to draw the workspace (AOI for time-series InSAR analysis) manually. The software will choose selected PS within the AOI to export.

4) Click "Convert" to convert the selected PS points to the format required for StaMPS processing.