

Tutorial on Atmospheric Delay Mitigation on Single (or few) Interferograms using Sarproz

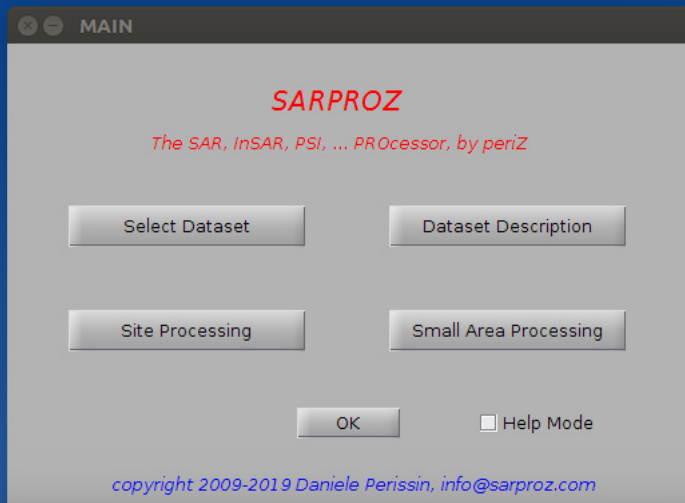
Mining activities detection in Poland

Data: 2 Sentinel-1 images

Objectives:

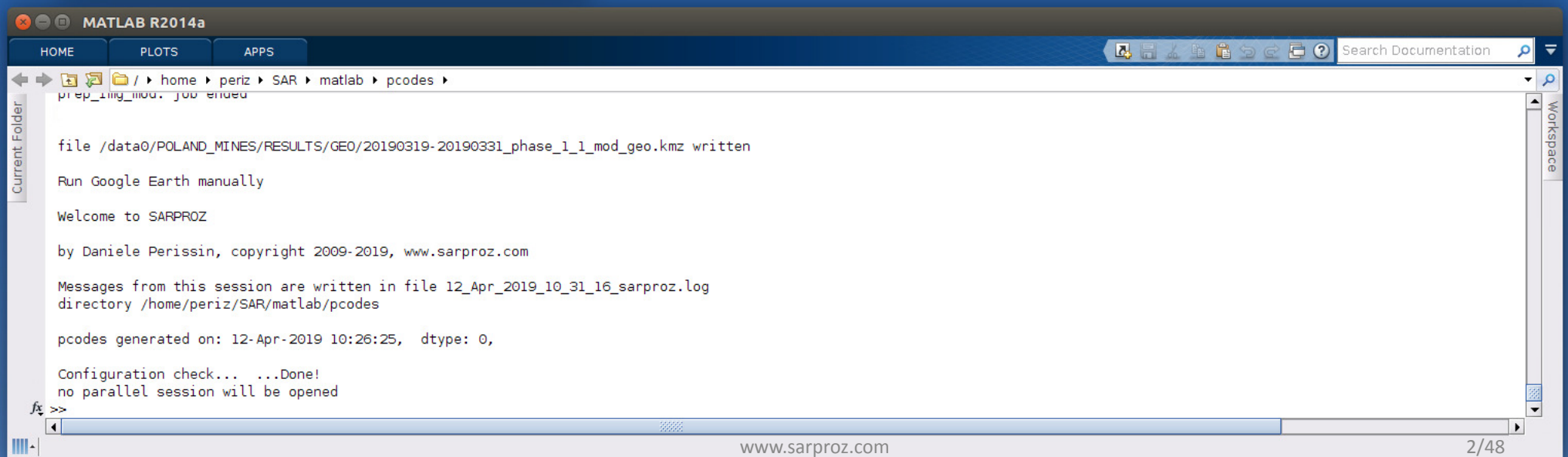
- understanding the concept behind atmospheric delay mitigation with few images
- Getting familiar with the new Sarproz module for extended data visualization/export

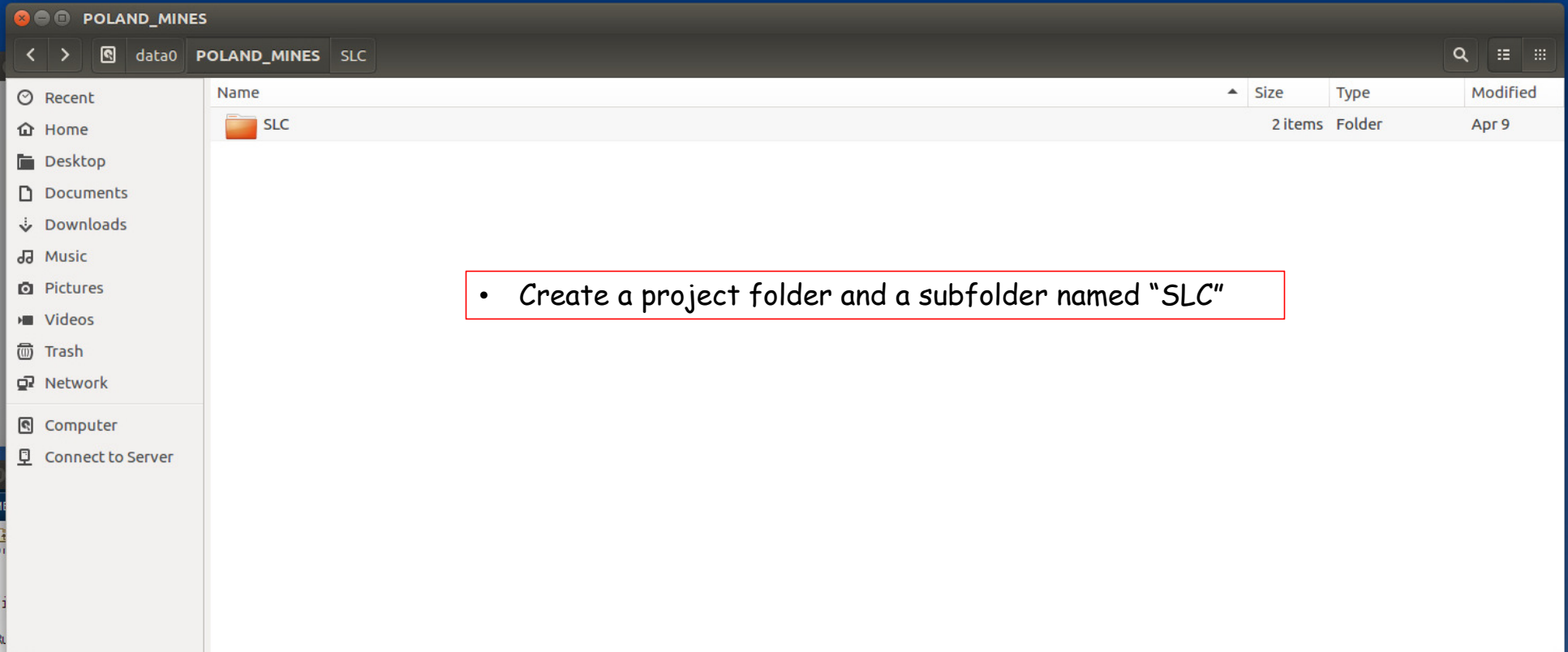
www.sarproz.com



- Run Sarproz and make sure you have a version later than 12 April 2019

Note: Keep the command prompt visible and take the time to read the messages from the software. This will save you time.





Welcome to SARPROZ

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Messages from this session are written in file 12_Apr_2019_10_31_16_sarproz.log
directory /home/periz/SAR/matlab/pcodes

pcodes generated on: 12-Apr-2019 10:26:25, dtype: 0,

Configuration check... ...Done!
no parallel session will be opened

fx >>

The screenshot shows a Linux desktop environment. At the top, a window titled "SLC" is open, displaying a file manager interface. The left sidebar shows a navigation pane with options like Recent, Home, Desktop, Documents, Downloads, Music, Pictures, Videos, Trash, Network, Computer, and Connect to Server. The main pane shows a directory listing for "POLAND_MINES" with two folders:

Name	Size	Type	Modified
S1B_IW_SLC__1SDV_20190319T163413_20190319T163440_015426_01CE3E_459D.SAFE	6 items	Folder	Mar 20
S1B_IW_SLC__1SDV_20190331T163413_20190331T163440_015601_01D3F4_8920.SAFE	6 items	Folder	Mar 31

Below the file manager, a terminal window is open, displaying the following text:

```
Welcome to SARPROZ  
by Daniele Perissin, copyright 2009-2019, www.sarproz.com  
Messages from this session are written in file 12_Apr_2019_10_31_16_sarproz.log  
directory /home/periz/SAR/matlab/pcodes  
pcodes generated on: 12-Apr-2019 10:26:25, dtype: 0,  
Configuration check... ..Done!  
no parallel session will be opened  
fx >>
```

Three red-bordered boxes are overlaid on the right side of the terminal window, containing the following text:

- Download the above Sentinel images and copy them in the SLC folder
- Note: in Windows you have to manually unzip the data. In Unix Sarproz unpacks data automatically
- Note: in this tutorial we will use only two Sentinel images. You could use more if you like with the same settings

The bottom of the terminal window shows a status bar with the URL www.sarproz.com and a page indicator 4/48.

The image displays the SARPROZ software interface, which is used for SAR data processing. The main window is titled "MAIN - /data0/POLAND_MINES/" and features a "Select Dataset" button. A secondary window, "DATASET SELECTION - /data0/POLAND_MINES/", is open, showing various parameters for dataset selection, including "Site Directory", "Data Set", "Master and Images Selection", and "Images Combination & Connections Selection". A third window, "SLC DATA Processing", is also open, showing options for "SLC Data List", "Channel Selection", "Data Selection", "Master Selection", "Area Selection", and "Data Processing".

1. Click on "Select Dataset"

2. Click on "Select" and choose the project directory previously created

3. The SLC data processing window will open up (if not, click on SLC data import)

file /data0/POLAND_MINES/RESULTS/GEO/20190319-20190331_phase_1_1_mod_geo.kmz written

Welcome to SARPROZ

by

Me

directory /home/periz/SAR/matlab/pcodes

pcodes generated on: 12

Configuration check...

no parallel session wil

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SARPROZ
The SAR, InSAR, PSI, ... PROCessor

MAIN - /data0/POLAND_MINES/

Dataset Selection - /data0/POLAND_MINES/

Site Directory: /data0/POLAND_MINES/ [Select]

Data Set

Samples	Lines	Images Nr
----	----	0

Primary: ----- Secondary: -----

Master and Images Selection

Master: [Dropdown] Bn: 3500 DC: 0.5 BtIn: -Inf BtFin: Inf

Images Combination & Connections Selection

Images Graph: [Dropdown] Coher Thres: 0 Delta Bn: Inf Delta Bt: Inf [Save As] [Plot Graph]

Current Selection

Nr of Selected Images: 0 Nr of Connections: 0

[SLC Data Import] [Advanced params] [Weather Module]

[Load Temp] [Load Aux Data] [Export Site Param]

[Manage Version] [Plot Dataset] [OK]

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SLC DATA Processing

SLC Data List

[Get Contents] [Untar] [Del tar] Sensor: SENTINEL-1B, Images Nr: 2 Single Polarization

Channel Selection

Polarization: VV Subswath: [1] [Go]

Data Selection

☒ All ☐ Update ☐ Ext. Orb. ☐ Deskewed [Set Orbits] [View Footprints] [View Parameters]

Master Selection

[Dropdown]

Area Selection

Latitude	Longitude	Radius [km]	Max Area
[]	[]	20	<input type="checkbox"/>

Samples	Lines	Rg OVS	Az OVS
[]	[]	1	1

Size: [] [] [View]

Data Processing

[Master Extraction] [View Master] [Stop [single img]]

Delta: 0 [Slaves Extraction] ☐ Ovw [View Ex. Sl.]

[Co-reg. param.] [Co-registration] [View Co-reg. Sl.]

SARPROZ (c) 2009-2019, the SAR PROCessor by periz [Refresh] [OK]

MATLAB R2014a

HOME PLOTS APPS

Current Folder: /home/periz/SAR/matlab

No files found in /data0/POLAND_MINES/SLC/ Analyzing directories

First 2 image Pol. List: VV, VV, Sensor: SENTINEL-1B, Single Polarization Sentinel TOPS detected: choose the subswath

1. Click on "Get Contents". The sw will detect the 2 Sentinel images

2. Select Subswath nr 2

3. Press the button "Go"

4. Press the button "Set Orbits"

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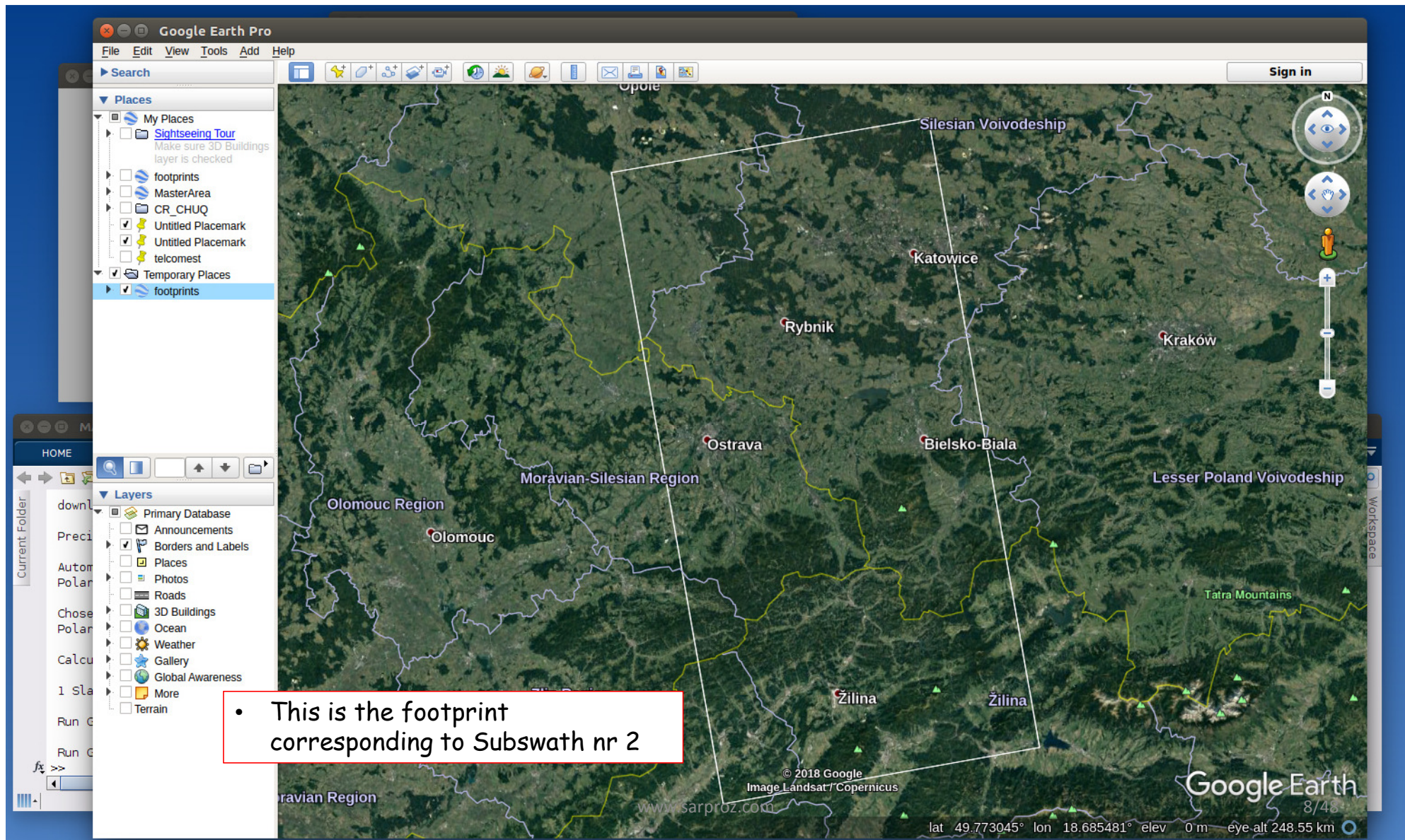
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The image displays the SARPROZ software interface, which is used for SAR data processing. The main window is titled "MAIN - /data0/POLAND_MINES/" and features a "Select Dataset" button. A "DATASET SELECTION - /data0/POLAND_MINES/" dialog box is open, showing fields for "Site Directory", "Data Set", "Master and Images Selection", and "Images Combination & Connections Selection". The "SLC DATA Processing" window is also open, showing "SLC Data List", "Channel Selection", "Data Selection", "Master Selection", "Area Selection", and "Data Processing" sections. The "View Footprints" button in the "Data Selection" section is highlighted with a red circle. The "Master Selection" and "Area Selection" sections are also highlighted with a red box. The "Data Processing" section contains buttons for "Master Extraction", "Slaves Extraction", "Co-reg. param.", "Co-registration", "View Master", "View Ex. Sl.", "View Co-reg. Sl.", "Stop [single img]", "Refresh", and "OK".

1. After setting the orbits, the software will populate the Master and Area panels

2. Click on View footprints. In windows, GoogleEarth will automatically open up. If not (or for other OS), open GoogleEarth manually and load the file indicated in the command prompt

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MAIN - /data0/POLAND_MINES/

Select Dataset

Site Processing

OK

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DATASET SELECTION - /data0/POLAND_MINES/

Site Directory: /data0/POLAND_MINES/ [Select]

Data Set

Samples	Lines	Images Nr
----	----	0

Primary ----- Secondary -----

Master and Images Selection

Master: [Dropdown]

Bn	DC	BtIn	BtFin
3500	0.5	-Inf	Inf

Images Combination & Connections Selection

Images Graph: [Dropdown]

Coh Thres	Delta Bn	Delta Bt
0	Inf	Inf

[Save As] [Plot Graph]

Current Selection

Nr of Selected Images: 0 Nr of Connections: 0

[SLC Data Import] [Advanced params] [Weather Module]

[Load Temp] [Load Aux Data] [Export Site Param]

[Manage Version] [Plot Dataset] [OK]

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SLC DATA Processing

SLC Data List

[Get Contents] ☒ Untar Sensor: SENTINEL-1B, Images Nr: 2
☒ Del tar Single Polarization

Channel Selection

Polarization: [VW] Subswath: [2] [Go]

Data Selection

Single Image

☒ All ☐ Update [Dropdown] [Get Weather]

☐ Ext. Orb. [Set Orbits] [View Footprints] [View Parameters]

☐ Deskewed

Master Selection

[20190319] [Dropdown]

No daily rain/snow data available

Area Selection

Latitude	Longitude	Radius [km]	Max Area
49.9696	18.6486	20	<input type="checkbox"/>

Samples	Lines	Rg OVS	Az OVS
Size 8790	3160	1	1
Final 8790	3160		

[View]

Data Processing

[Master Extraction] [View Master] [Stop [single img]]

Delta: [0] [Slaves Extraction] ☐ Ovw [View Ex. Sl.]

[Co-reg. param.] [Co-registration] [View Co-reg. Sl.]

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[Refresh] [OK]

MATLAB R2014a

HOME PLOTS APPS

/ home periz SAR matlab

Reading External Orbits

Restitute Orbit is used for S1B and 2019/03/31

Automatic Master: 20190319

Polari

Chosen

Polari

Calculating the Area given a radius of 20 km

1 Slave images have not been extracted!!

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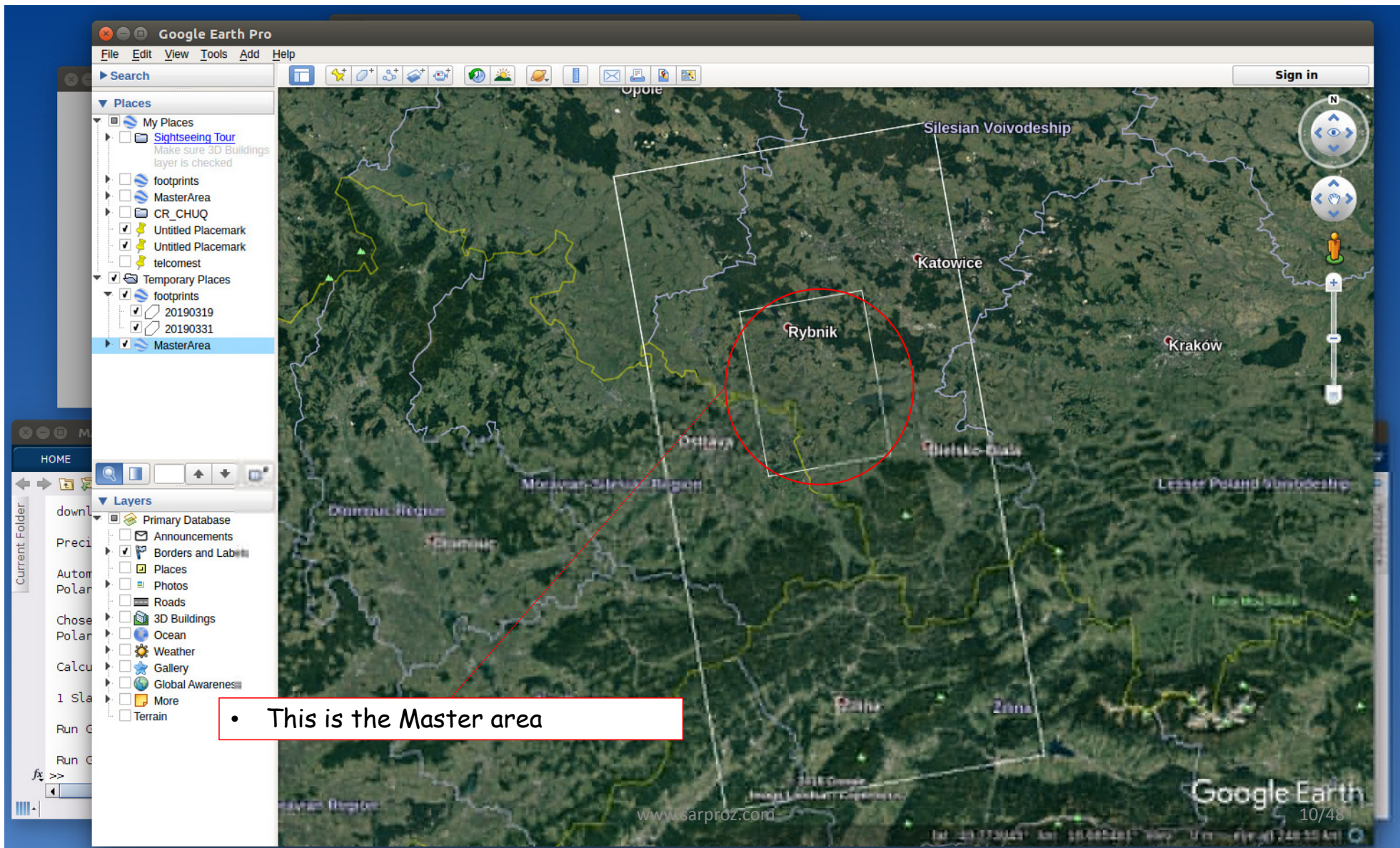
Workspace

Current Folder

005942.E0F

1. Set the center of the area to extract to the coordinates here indicated. Keep the 20km radius

2. Click View and open GoogleEarth if it does not start automatically



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MAIN - /data0/POLAND_MINES/

Select Dataset

Site Processing

OK

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DATASET SELECTION - /data0/POLAND_MINES/

Site Directory: /data0/POLAND_MINES/ [Select]

Data Set

Samples	Lines	Images Nr
----	----	0

Primary ----- Secondary -----

Master and Images Selection

Master	Bn	DC	BtIn	BtFin
[Dropdown]	3500	0.5	-Inf	Inf

Images Combination & Connections Selection

Images Graph	Coher Thres	Delta Bn	Delta Bt
[Dropdown]	0	Inf	Inf

[Save As] [Plot Graph]

Current Selection

Nr of Selected Images: 0 Nr of Connections: 0

[SLC Data Import] [Advanced params] [Weather Module]

[Load Temp] [Load Aux Data] [Export Site Param]

[Manage Version] [Plot Dataset] [OK]

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SLC DATA Processing

SLC Data List

[Get Contents] ☒ Untar Sensor: SENTINEL-1B, Images Nr: 2
☒ Del tar Single Polarization

Channel Selection

Polarization: [VV] Subswath: [2] [Go]

Data Selection

Single Image

☒ All ☐ Update [Dropdown] [Get Weather]

☐ Ext. Orb. [Set Orbits] [View Footprints] [View Parameters]

☐ Deskewed

Master Selection

[20190319] [Dropdown]

No daily rain/snow data available

Area Selection

Latitude	Longitude	Radius [km]	Max Area
49.9696	18.6486	20	<input type="checkbox"/>

Samples	Lines	Rg OVS	Az OVS
Size 8790	3160	1	1

Final 8790 3160 [View]

Data Processing

[Master Extraction] [View Master] [Stop [single img]]

Delta 0 [Slaves Extraction] ☐ Ovw [View Ex. Sl.]

[Co-reg. param.] [Co-registration] [View Co-reg. Sl.]

SARPROZ (c) 2009-2019, the SAR PROCessor by periz [Refresh] [OK]

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HOME PLOTS APPS

Current Folder: /home/periz/SAR/matlab

Workspace

```
SLC data extraction
setimageconf: converting from SLC data
```

1. Click on "Master Extraction"

2. Optionally, you can plot the Master

1 Slave images have not been extracted!!

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MAIN - /data0/POLAND_MINES/

Select Dataset

Site Processing

OK

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DATASET SELECTION - /data0/POLAND_MINES/

Site Directory: /data0/POLAND_MINES/ [Select]

Data Set

Samples	Lines	Images Nr
----	----	0

Primary ----- Secondary -----

Master and Images Selection

Master: [Dropdown] Bn: 3500 DC: 0.5 BtIn: -Inf BtFin: Inf

Images Combination & Connections Selection

Images Graph: [Dropdown] Coher Thres: 0 Delta Bn: Inf Delta Bt: Inf [Save As] [Plot Graph]

Current Selection

Nr of Selected Images: 0 Nr of Connections: 0

[SLC Data Import] [Advanced params] [Weather Module]

[Load Temp] [Load Aux Data] [Export Site Param]

SLC DATA Processing

SLC Data List

[Get Contents] ☒ Untar Sensor: SENTINEL-1B, Images Nr: 2 ☒ Del tar Single Polarization

Channel Selection

Polarization: [V] Subswath: 2 [Go]

Data Selection

☒ All ☐ Update [Dropdown] [Get Weather]

☐ Ext. Orb. [Set Orbits] [View Footprints] [View Parameters]

☐ Deskewed

Master Selection

[20190319] [No daily rain/snow data available]

Area Selection

Latitude	Longitude	Radius [km]	Max Area
49.9696	18.6486	20	<input type="checkbox"/>

Samples	Lines	Rg OVS	Az OVS
Size 8790	3160	1	1
Final 8790	3160		

[View]

Data Processing

[Master Extraction] [View Master] [Stop [single img]]

Delta: 0 [Slaves Extraction] ☐ Ovw [View Ex. Sl.]

[Co-reg. param.] [Co-registration] [View Co-reg. Sl.]

[Refresh] [OK]

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MATLAB R2014a

HOME PLOTS APPS

Current Folder: /home/periz/SAR/matlab/pcodes

1 Slave Images have not been extracted!!

Processing the SLC data Preparation

Extracting Slave Images

SLC data

Extract Slave from a different look: date 20190331...Done.

The Processing concluded successfully, here a specific message:

SLC data Preparation: job ended
Elapsed Time: 17 seconds
12-Apr-2019 10:53:40

1. Click on "Salve Extraction"

2. Optionally, you can plot the Slave

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Figure 3

Image 20190331

Sample [pix] 1000 2000 3000 4000 5000 6000 7000 8000

Line [pix] 500 1000 1500 2000 2500 3000

2.4 1.8 1.2 0.6 0

1. Click on "Co-registration"

2. Optionally, you can plot the co-registered slave

3. When done, click on "OK" to close the module

Note: Instead of clicking on Master and Slave extraction, you can directly click on "co-registration", the sw will automatically extract Master and Slave, if needed.

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MAIN - /data0/POLAND_MINES/

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Select Dataset

Site Processing

OK

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HOME PLOTS APPS

File /data0/POLAND_MINES/RESULTS/MATLAB/

file /data0/POLAND_MINES/RESULTS/MATLAB/MatrIncImgAll is missing. You can generate it via "Full Graph Coherence Estimation"

The tool detected that there are files which cannot be modified by users other than the creator

writing sparse file /data0/POLAND_MINES/RESULTS/PSType.mat

writing sparse file /data0/POLAND_MINES/RESULTS/EDem.mat

file /data0/POLAND_MINES/RESULTS/MATLAB/MatrIncImgAll is missing. You can generate it via "Full Graph Coherence Estimation"

One-Sensor STAR Images Graph

fx >>

DATASET SELECTION - /data0/POLAND_MINES/

Site Directory: /data0/POLAND_MINES/ [Select]

Data Set

Samples	Lines	Images Nr
8790	3160	2

Primary: SENTINEL-1B Secondary: -----

Master and Images Selection

Master	Bn	DC	BtIn	BtFin
20190319 0 0.00 0 22...	3500	0.5	-Inf	Inf

Images Combination & Connections Selection

Images Graph	Coher Thres	Delta Bn	Delta Bt
STAR, 1 sensor	0	Inf	Inf

Save As Plot Graph

Current Selection

Nr of Selected Images: 2 Nr of Connections: 2

SLC Data Import Advanced params Weather Module

Load Temp Load Aux Data Export Site Param

Manage Version Plot Dataset OK

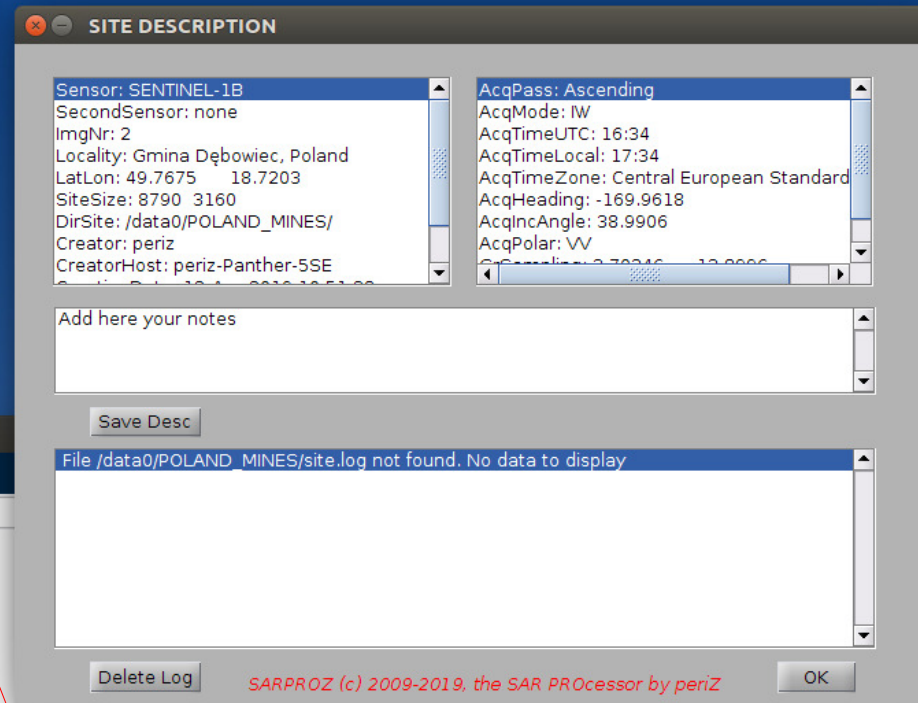
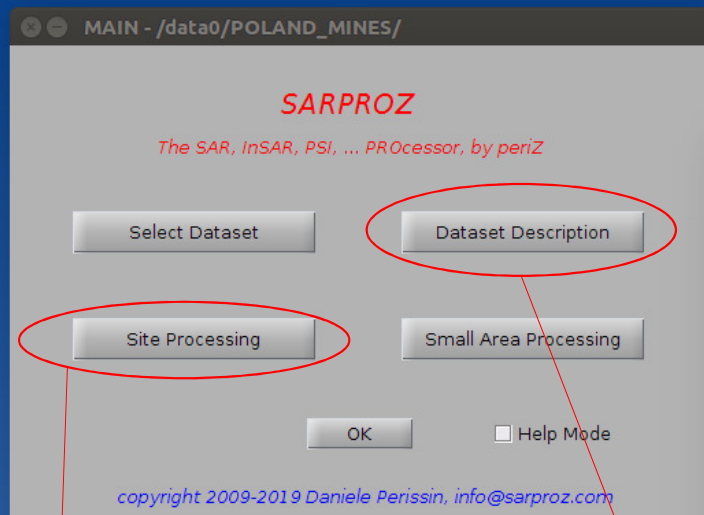
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1. After closing the SLC processing module, if the job was successful, the sw will populate the details in the module above

2. Click "OK" to close this window

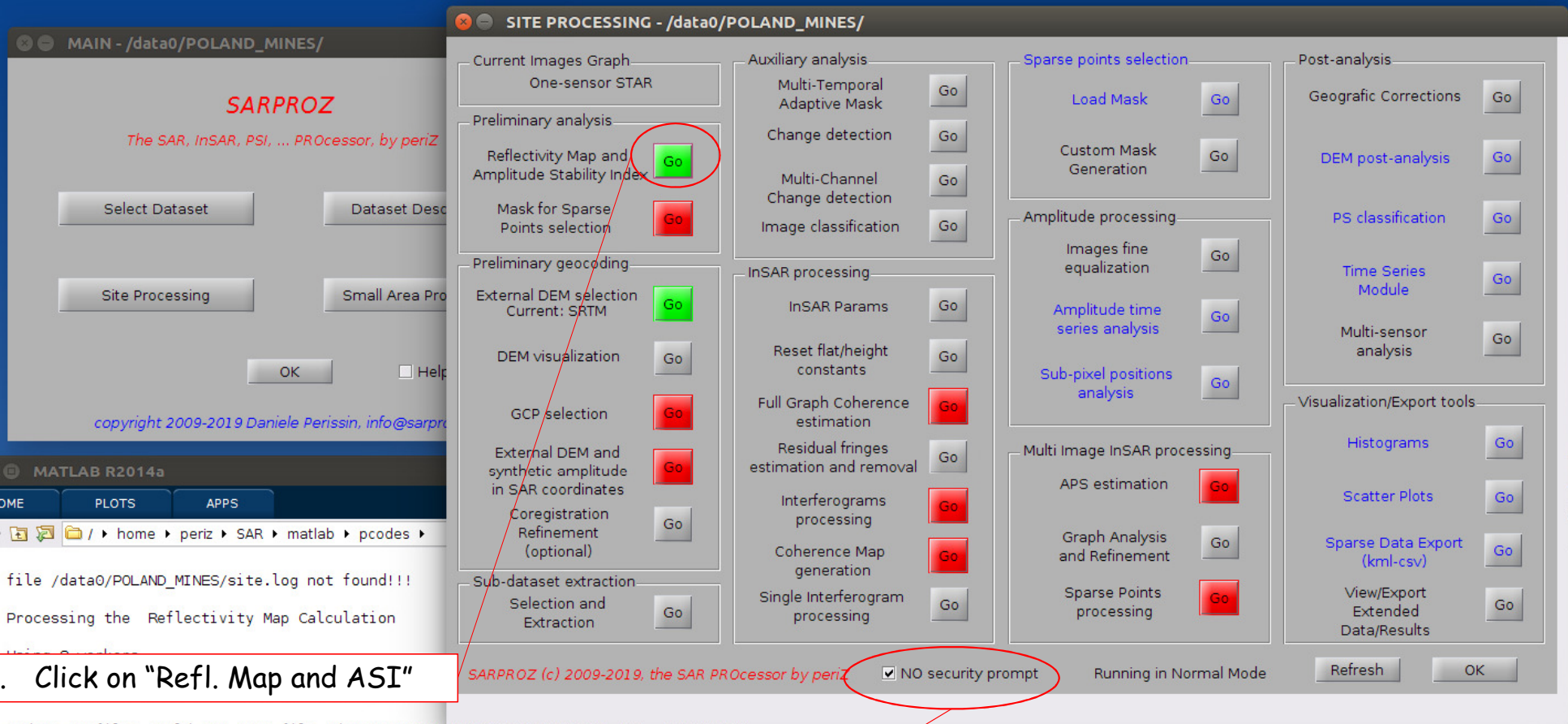
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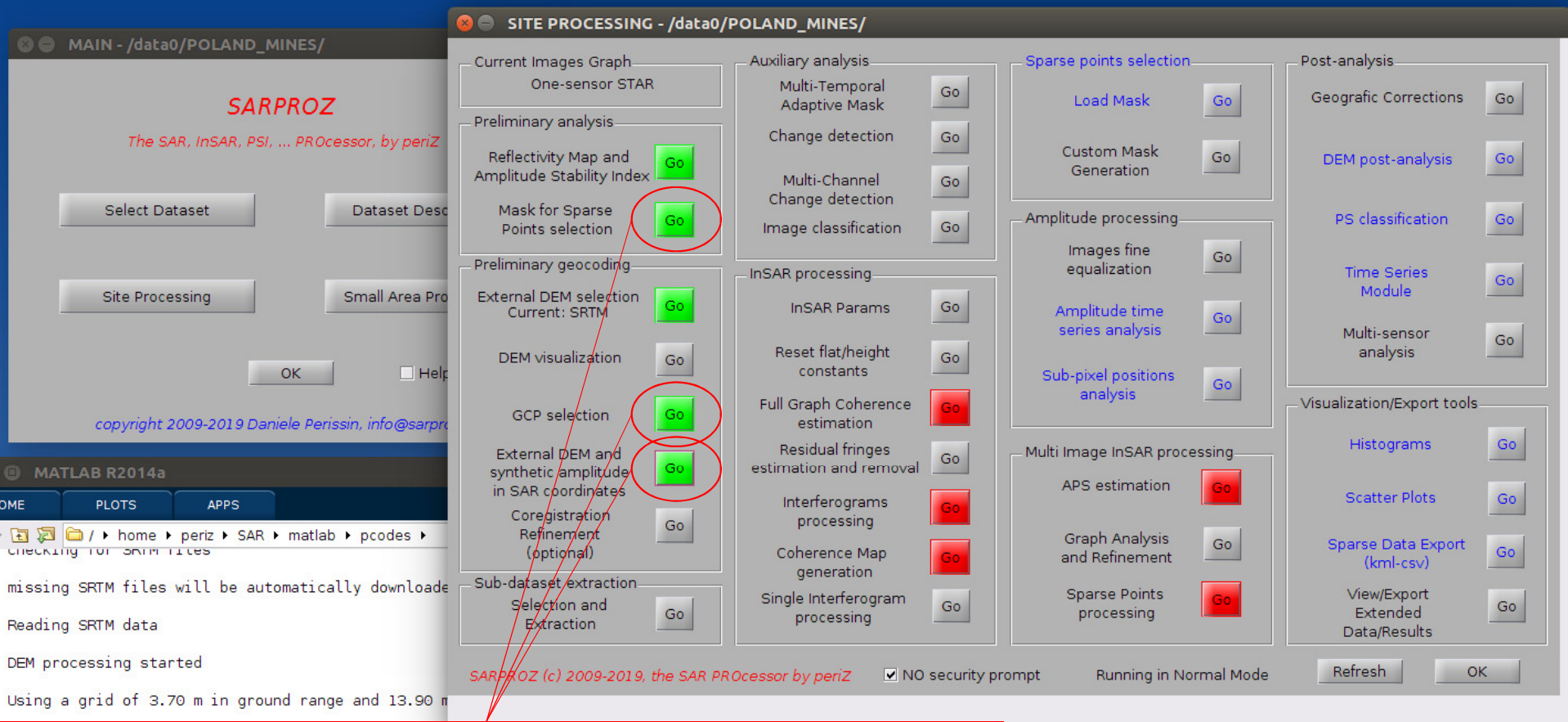


1. Optionally, you can view a brief Dataset Description by clicking on the corresponding button

2. Click on Site Processing to move on to the next steps



Note: check other tutorials to see these steps more in detail



1. Click in sequence on:

Mask for sp. Pts selection, GCP selection, ext DEM in SAR coords
 GCP selection: click on "keep current orbits" in the GCP panel
 (for more details, check other tutorials)

12-Apr-2019 11:00:44

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Select Dataset Dataset D

Site Processing Small Area

OK

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MATLAB R2014a

HOME PLOTS APPS

Current Folder: /home/periz/SAR/matlab/pcodes

Checking for SRTM files

missing SRTM files will be automatically downlo

Reading SRTM data

DEM processing started

Using a grid of 3.70 m in ground range and 13.90 m in ground azimuth

preparation of files for quick view: job ended

update_parfile: could not open file /data0/POLAND_MINES/InputParFile.txt. ABORTING!!

The

DE

El

12-Apr-2019 11:00:44

>>

SITE PROCESSING - /data0/POLAND_MINES/

Current Images Graph
One-sensor STAR

Preliminary analysis

Reflectivity Map and Amplitude Stability Index Go

Mask for Sparse Points selection Go

Preliminary geocoding

External DEM selection Current: SRTM Go

DEM visualization Go

GCP selection Go

External DEM and synthetic amplitude in SAR coordinates Go

Coregistration Refinement (optional) Go

Sub-dataset extraction Selection and Extraction Go

Auxiliary analysis

Multi-Temporal Adaptive Mask Go

Change detection Go

Multi-Channel Change detection Go

Image classification Go

InSAR processing

InSAR Go

Reset file consistency Go

Full Graph estimation Go

Residual estimation Go

Interferometric processing Go

Coherence generation Go

Single Interferogram processing Go

Sparse points selection

Load Mask Go

Custom Mask Generation Go

Amplitude processing

Post-analysis

Geographic Corrections Go

DEM post-analysis Go

PS classification Go

Time Series Module Go

Multi-sensor analysis Go

Visualization/Export tools

Histograms Go

Scatter Plots Go

Sparse Data Export (kml-csv) Go

View/Export Extended Data/Results Go

Refresh OK

PLOT PARAMETERS - /data0/POLAND_MINES/

Data to Plot

Mode Parameter

Parameter

Abs/Phase

Options

Saturation Auto Min Max

Zero Reference none Lat Lon

InSAR Conversion: Mask: Thres. none none 0 APS Remo...

Output: Auto Colorbar Rev...

Export in GEOGRAPHIC coordinates

Mode File type Rg Az Export

Geocode Kml 1 1

View/Export in SAR coordinates

Plot Jpg/Png OK

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1. To check the outputs of the previous processing steps, use the "view/export extended Data/results" module

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MAIN - /data0/POLAND_MINES/

Select Dataset Dataset D

Site Processing Small Area

OK

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1. Keep the "Parameter" mode

2. Choose "Refl Map" from the menu

HOME PLOTS APPS

Current Folder

Reading SRTM data

DEM processing started

Using a grid of 3.70 m in ground range and 13.90 m in ground azimuth

preparation of files for quick view: job ended

update_parfile: could not open file /data0/POLAND_MINES/InputParFile.txt. ABORTING!!

The Processing concluded successfully, here a specific message:

DEM in SAR Coordinates : job ended

Elapsed Time: 39 seconds

12-Apr-2019 11:00:44

fx >>

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SITE PROCESSING - /data0/POLAND_MINES/

Current Images Graph
One-sensor STAR

Preliminary analysis

Reflectivity Map and Amplitude Stability Index Go

Mask for Sparse Points selection Go

Preliminary geocoding

External DEM selection Current: SRTM Go

DEM visualization Go

GCP selection Go

External DEM and Amplitude Stability Index Go

Coregistration Refinement (optional) Go

Extraction Go

Auxiliary analysis

Multi-Temporal Adaptive Mask Go

Change detection Go

Multi-Channel Change detection Go

Image classification Go

Sparse points selection

Load Mask Go

Custom Mask Generation Go

Post-analysis

Geographic Corrections Go

DEM post-analysis Go

PS classification Go

Time Series Module Go

Multi-sensor analysis Go

Visualization/Export tools

Histograms Go

Scatter Plots Go

Sparse Data Export (kml-csv) Go

View/Export Extended Data/Results Go

Refresh OK

PLOT PARAMETERS - /data0/POLAND_MINES/

Data to Plot

Mode Parameter

Parameter

Abs/Phase

Options

Saturation Auto

Zero Reference none

InSAR Conversion: none

Output: Auto

Export in GEOGRAPHIC Mode

Geocode

View/Export in SAR c

Plot

Export

OK

Refl. map

Pos Mean

Pos Master

Mu Pos

Sigma Pos

Coher Second

MAIN - /data0/POLAND_MINES/

SARPROZ

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Select Dataset

Dataset D

Site Processing

Small Area

OK

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MATLAB R2014a

HOMEPLOTSAPPS

Current Folder: /home/periz/SAR/matlab/pcodes/

Checking for SRTM files

missing SRTM files will be automatically downlo

Reading SRTM data

DEM processing started

Using a grid of 3.70 m in ground range and 13.90 m in ground azimuth

preparation of files for quick view: job ended

1. Click on "plot" to see the Refl Map

The Processing concluded successfully, here a specific message:

DEM in SAR Coordinates : job ended

Elapsed Time: 39 seconds

12-Apr-2019 11:00:44

fx >>

SITE PROCESSING - /home/POLAND_MINES/

Current Images Graph - One-sensor STA

Preliminary analysis - Reflectivity Map and Amplitude Stability Index

Mask for Sparse Points selection

Preliminary geocoding - External DEM selection Current: SRTM

DEM visualization

GCP selection

External DEM and synthetic amplitude in SAR coordinates

Coregistration Refinement (optional)

Sub-dataset extraction Selection and Extraction

Single Int

Output: Auto

Export in GEOGRAPHIC coordinates Mode: Geocode File type: Kml Rg: 1 Az: 1

View/Export in SAR coordinates Plot Jpg/Png

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Figure 1

Reflectivity Map

Sample [pix] 1000 2000 3000 4000 5000 6000 7000 8000

Line [pix] 500 1000 1500 2000 2500 3000

2.4 1.8 1.2 0.6 0

Colorbar Rev...

Export

OK

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Post-analysis

Geografic Corrections Go

DEM post-analysis Go

PS classification Go

Time Series Module Go

Multi-sensor analysis Go

Visualization/Export tools

Histograms Go

Scatter Plots Go

Sparse Data Export (kml-csv) Go

View/Export Extended Data/Results Go

Refresh OK

Workspace

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Select Dataset Dataset D

Site Processing Small Area

OK

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SITE PROCESSING - /data0/POLAND_MINES/

Current Images Graph
One-sensor STAR

Preliminary analysis
Reflectivity Map and Amplitude Stability Index Go
Mask for Sparse Points selection Go

Preliminary geocoding
External DEM selection Current: SRTM Go
DEM visualization Go
GCP selection Go
External DEM and synthetic amplitude in SAR coordinates Go
Coregistration Refinement (optional) Go

Auxiliary analysis
Multi-Temporal Adaptive Mask Go
Change detection Go
Multi-Channel Change detection Go
Image classification Go

Sparse points selection
Load Mask Go
Custom Mask Generation Go

Post-analysis
Geographic Corrections Go
DEM post-analysis Go
PS classification Go
Time Series Module Go
Multi-sensor analysis Go

Visualization/Export tools
Histograms Go
Scatter Plots Go
Sparse Data Export (kml-csv) Go
View/Export Extended Data/Results Go

Refresh OK

PLOT PARAMETERS - /data0/POLAND_MINES/

Data to Plot
Mode Parameter
Parameter Refl. map
Abs/Phase Coher Second
Coher First
Height
Latitude
Longitude
Temp-ampl
AzPos Mean
AzPos Master
Mu AzPos
Sigma AzPos
PS type
PS type weight
Amp. Stab. Index 1-Sigma
Synt. Coher.
Spatial Coher.
Synthetic Amplitude
Eff. Bn
Eff. Bt
Amp. Stab. Mu/Sigma

Options
Saturation Auto
Zero Reference none
InSAR Conversion: none
Output: Auto

Export in GEOGRAPH Mode
Geocode
View/Export in SAR c
Plot

Export OK

1. Choose "Ext. DEM height" from the menu

SARPROZ (c) 2009-2019, the SAR PROCessor by periz

DEM processing started

Using a grid of 3.70 m in ground range and 13.90 m in ground azimuth

preparation of files for quick view: job ended

update_parfile: could not open file /data0/POLAND_MINES/InputParFile.txt. ABORTING!!

The Processing concluded successfully, here a specific message:

DEM in SAR Coordinates : job ended
Elapsed Time: 39 seconds
12-Apr-2019 11:00:44

www.sarproz.com

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MAIN - /data0/POLAND_MINES/

SARPROZ
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Select Dataset Dataset D

Site Processing Small Area

OK

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MATLAB R2014a

HOME PLOTS APPS

Current Folder: /home/periz/SAR/matlab/pcodes

Checking for SRTM files

missing SRTM files will be automatically downlo

Reading SRTM data

DEM processing started

Using a grid of 3.70 m in ground range and 13.90 m in ground azimuth

preparation of files for quick view: job ended

1. Click on "plot" to see the height

The Processing concluded successfully, here a specific message:

DEM in SAR Coordinates : job ended
Elapsed Time: 39 seconds
12-Apr-2019 11:00:44

SITE PROCESSING

Current Images Graph One-sensor STA

Preliminary analysis

Reflectivity Map and Amplitude Stability Index

Mask for Sparse Points selection

Preliminary geocoding

External DEM selection Current: SRTM

DEM visualization

GCP selection

External DEM and synthetic amplitude in SAR coordinates

Coregistration Refinement (optional)

Sub-dataset extraction Selection and Extraction

Single Int proc

Output: Auto

Colorbar Rev...

Export in GEOGRAPHIC coordinates Mode File type

Geocode Kml

Rg Az 1 1

Export

View/Export in SAR coordinates

Plot Jpg/Png

OK

Figure 1

Ext. Height

Sample [pix] 1000 2000 3000 4000 5000 6000 7000 8000

Line [pix] 500 1000 1500 2000 2500 3000

360 320 280 240 200

Post-analysis

Geographic Corrections Go

DEM post-analysis Go

PS classification Go

Time Series Module Go

Multi-sensor analysis Go

Visualization/Export tools

Histograms Go

Scatter Plots Go

Sparse Data Export (kml-csv) Go

View/Export Extended Data/Results Go

Refresh OK

Workspace

file.txt. ABORTING!!

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The screenshot displays the SARPROZ software interface, which is a MATLAB-based tool for SAR data processing. The main window is titled 'MAIN - /data0/POLAND_MINES/' and features a 'SARPROZ' logo and the tagline 'The SAR, InSAR, PSI, ... PROCessor, by periz'. Below the logo are buttons for 'Select Dataset', 'Dataset Description', 'Site Processing', and 'Small Area Processing'. A copyright notice at the bottom reads 'copyright 2009-2019 Daniele Perissin, info@sarproz.com'.

The 'SITE PROCESSING - /data0/POLAND_MINES/' window is open, showing various processing modules. The 'InSAR processing' section is highlighted, and the 'InSAR Params' button is circled in red. A red arrow points from the text box below to this button. Other modules visible include 'Current Images Graph', 'Preliminary analysis', 'Preliminary geocoding', 'Sub-dataset extraction', 'Auxiliary analysis', 'Sparse points selection', 'Amplitude processing', 'Multi Image InSAR processing', 'Post-analysis', and 'Visualization/Export tools'.

The MATLAB R2014a command window shows the following output:

```
checking for SRTM files
missing SRTM files will be automatically downloaded
Reading SRTM data
DEM processing started
Using a grid of 3.70 m in ground range and 13.90 m
```

At the bottom of the SARPROZ window, there is a status bar with the text 'SARPROZ (c) 2009-2019, the SAR PROCessor by periz', a checkbox for 'NO security prompt' (checked), and the text 'Running in Normal Mode'. There are also 'Refresh' and 'OK' buttons.

1. Now we want to generate the interferogram(s). Instead of using the single interf. module we run the function that processes all interfeorograms loaded under the current images graph (even if in this example we have 1 single interferogram...): "interferograms processing". Before that, we firstly click on "InSAR params" to choose the processing options.

12-Apr-2019 11:00:44

www.sarproz.com

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The screenshot displays the SARPROZ software interface. The main window is titled "MAIN - /data0/POLAND_MINES/" and features a "Site Processing" button. Overlaid on this is the "InSAR Parameters - /data0/POLAND_MINES/" dialog box. The dialog box has several sections: "Filtering and Coherence Options" (Presets: Goldstein Mod, Windows Type: Fixed, Filter Type: none, Filter Ratio: Fixed, Filter Ratio Value: 0.5, Noise: 0, Exclude Areas: none, Exclude Threshold: 0.05, Norm Fact: 1, Frequency Enhancement: LocalCoher, Enhancement Value: 0.5, Additional Smo. Size: 3, 3, Output Coherence: pre-filtering, Interf/Coherence: ampl.-weighted, Coherence Window: 15, 15), "Interferometric Options" (Bistatic Configurati..., Update new images ..., Flattening, DEM Removal, ML Rg-Az: 1, 1, Read Interf, Unwrap: none, Convers.: none, Mask: none, Thres.: 0), and "Post-analysis" (Geographic Corrections, DEM post-analysis, PS classification, Time Series Module, Multi-sensor analysis). The "Site Processing" window also shows "Preliminary analysis" and "Sparse points selection" options. The MATLAB R2014a command window at the bottom shows the following output:

```
HOME PLOTS APPS
Current Folder: /home/periz/SAR/matlab/pcodes
Checking for SRTM files
missing SRTM files will be automatically downlo
Reading SRTM data
DEM processing started
Using a grid of 3.70 m in ground range and 13.50 m in ground azimuth
update_parfile: could not open file /data0/POLAND_MINES/InputParFile.txt. ABORTING!!
The Processing concluded s
DEM in SAR Coordinates :
Elapsed Time: 39 seconds
12-Apr-2019 11:00:44
```

1. We are going to keep the default options: Goldstein mod filter, no Multi-looking

Note: since we are not changing options, there was no need to open the above panel. We did it just to stress that you need to open this module before running the "interferogram processing" to change processing options

www.sarproz.com

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The screenshot displays the SARPROZ software interface, which is a MATLAB-based application for SAR data processing. The main window, titled "MAIN - /data0/POLAND_MINES/", features a "SARPROZ" logo and the tagline "The SAR, InSAR, PSI, ... PROCESSOR, by periz". It includes buttons for "Select Dataset", "Dataset Description", "Site Processing", and "Small Area Processing". A copyright notice at the bottom reads "copyright 2009-2019 Daniele Perissin, info@sarproz.com".

Overlaid on this is the "SITE PROCESSING - /data0/POLAND_MINES/" window, which contains several panels of processing options, each with a "Go" button:

- Current Images Graph:** One-sensor STAR (highlighted with a red circle).
- Preliminary analysis:** Reflectivity Map and Amplitude Stability Index, Mask for Sparse Points selection (both green "Go" buttons).
- Preliminary geocoding:** External DEM selection (Current: SRTM), DEM visualization, GCP selection, External DEM and synthetic amplitude in SAR coordinates, Coregistration Refinement (optional), Sub-dataset extraction (all green "Go" buttons).
- Auxiliary analysis:** Multi-Temporal Adaptive Mask, Change detection, Multi-Channel Change detection, Image classification (all grey "Go" buttons).
- InSAR processing:** InSAR Params, Reset flat/height constants, Full Graph Coherence estimation (red "Go" button), Residual fringes estimation and removal, Interferograms processing (red "Go" button, highlighted with a red circle), Coherence Map generation, Single Interferogram processing (all grey "Go" buttons).
- Sparse points selection:** Load Mask, Custom Mask Generation (both grey "Go" buttons).
- Amplitude processing:** Images fine equalization, Amplitude time series analysis, Sub-pixel positions analysis (all grey "Go" buttons).
- Multi Image InSAR processing:** APS estimation, Graph Analysis and Refinement, Sparse Points processing (all red "Go" buttons).
- Post-analysis:** Geographic Corrections, DEM post-analysis, PS classification, Time Series Module, Multi-sensor analysis (all grey "Go" buttons).
- Visualization/Export tools:** Histograms, Scatter Plots, Sparse Data Export (kml-csv), View/Export Extended Data/Results (all grey "Go" buttons).

At the bottom of the "SITE PROCESSING" window, there is a status bar with the text "SARPROZ (c) 2009-2019, the SAR PROCESSOR by periz", a checkbox for "NO security prompt" (checked), and the text "Running in Normal Mode". Buttons for "Refresh" and "OK" are also present.

In the bottom left, a MATLAB R2014a command window shows the following output:

```
HOME PLOTS APPS
>> /home/periz/SAR/matlab/pcodes/
checking for SRTM files
missing SRTM files will be automatically downloaded
Reading SRTM data
DEM processing started
Using a grid of 3.70 m in ground range and 13.90 m in azimuth range
```

A red box highlights the following instruction:

1. Now you can click on "interferograms processing" to generate the interferogram(s). Interferograms are processed according to the current loaded images graph. At this moment, the "One-sensor STAR" graph is loaded.

The Processing concluded successfully, here a specific message:

```
DEM in SAR Coordinates : job ended
Elapsed Time: 39 seconds
12-Apr-2019 11:00:44
```

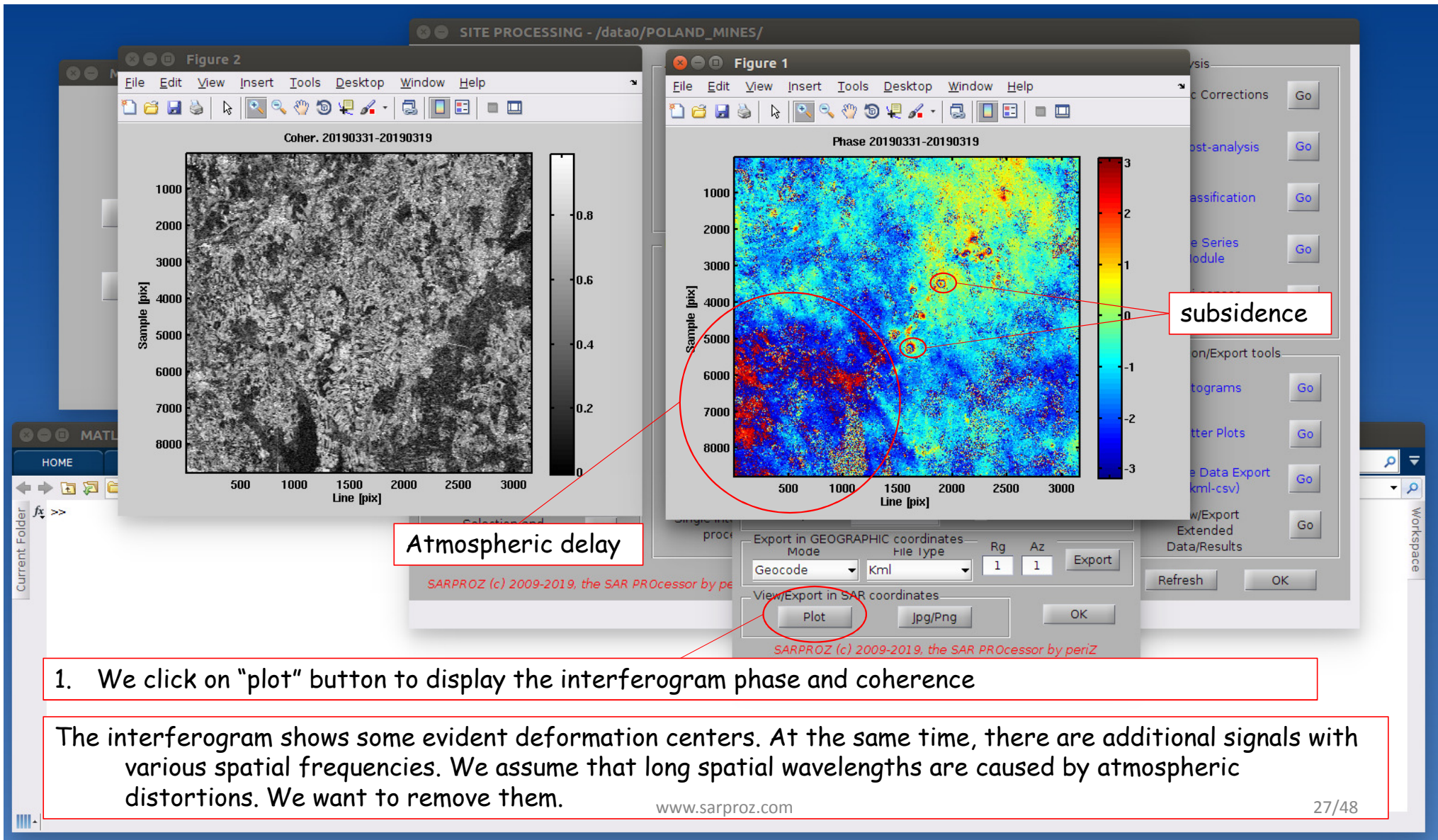
The bottom of the image shows the website "www.sarproz.com" and the page number "25/48".

The screenshot displays the SARPROZ software interface. The main window is titled 'MAIN - /data0/POLAND_MINES/' and features a 'SARPROZ' logo and several buttons: 'Select Dataset', 'Dataset D...', 'Site Processing', and 'Small Area...'. A 'MATLAB R2014a' window is also visible in the background. The 'PLOT PARAMETERS - /data0/POLAND_MINES/' dialog box is open, showing various settings for plotting. The 'Data to Plot' section has 'Mode' set to 'Single Interferogram'. The 'Interferogram' list shows two entries: '20190319-20190319' and '20190331-20190319', with the latter selected. The 'Options' section includes 'Saturation' set to 'Auto', 'Zero Reference' set to 'none', and 'InSAR Conversion' set to 'none'. The 'Export in GEOGRAPHIC coordinates' section shows 'Mode' set to 'Geocode' and 'File type' set to 'Kml'. The 'View/Export Extended Data/Results' button is circled in red. Three numbered instructions are provided at the bottom:

1. To plot the processed interferogram, we click on "view/export extended data/results"
2. We choose the "single interferogram" mode
3. We select the interferogram we want to plot

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MAIN - /data0/POLAND_MINES/

Select Dataset Dataset D

Site Processing Small Area

OK

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SITE PROCESSING - /data0/POLAND_MINES/

Current Images Graph One-sensor STAR

Auxiliary analysis Multi-Temporal Adaptive Mask Go Change detection Go Multi-Channel Go

Preliminary analysis Reflectivity Map and Amplitude Stability Index Go Mask for Sp Points select Preliminary geo External DEM s Current: St DEM visualiz GCP select External DEM synthetic am in SAR coord Coregistra Refineme (optiona Sub-dataset ex Selection: Extractio

InSAR Parameters - /data0/POLAND_MINES/

Filtering and Coherence Options

Presets Goldstein Mod

Windows Type Fixed

Fix Window Size 15 15

Filter Type none

Filter Ratio Fixed

Filter Ratio Value 0.5 Noise

Exclude Areas none

Exclude Threshold 0.05 Norm Fact

Frequency Enhancement LocalCoher

LF Removal Enhancement Value 0.5

Additional Smo. Size 3 3

Output Coherence pre-filtering

Interf/Coherence ampl.-weighted

Coherence Window 15 15

Interferometric Options

☐ Bistatic Configurati...

☐ Update new images ...

☒ Flattening

☒ DEM Removal

ML Rg-Az: 25 25

☐ Read Interf

Unwrap: none

Convers.: none

Mask: none

Thres. 0

Save Ok

Post-analysis

Geographic Corrections Go

DEM post-analysis Go

PS classification Go

Time Series Module Go

Multi-sensor analysis Go

Visualization/Export tools

Histograms Go

Scatter Plots Go

Sparse Data Export (kml-csv) Go

View/Export Extended Data/Results Go

Normal Mode Refresh OK

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MATLAB R2014a

HOME PLOTS APPS

/ > home > periz > SAR > matlab > pcodes

Current Folder >>

Workspace

1. How to remove long spatial wavelengths? Firstly, we try to isolate them. So, we filter out short wavelengths. To do so, we re-open the "insar params" module and we set the multi-looking factor as 25*25 (you can change these numbers according to your case/feeling)

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The screenshot displays the SARPROZ software interface, specifically the 'SITE PROCESSING' window. The window is titled 'SITE PROCESSING - /data0/POLAND_MINES/'. It contains several panels with various processing options, each with a 'Go' button. The 'Interferograms processing' button is highlighted with a red circle and a red arrow. A text box at the bottom explains the color coding of the buttons.

1. We run again the "interferograms processing" function

Note: after changing the multi-looking factor, the "interferograms processing" turned red again. It's green when interferograms are present, red when interferograms are missing. The software gives different names to multi-looked interferograms. So, it can distinguish between multi-looked and full resolution (single-look) interferograms

www.sarproz.com 29/48

MAIN - /data0/POLAND_MINES/

SARPROZ

The SAR, InSAR, PSI, ... PROCESSOR, by periz

Select Dataset Dataset D

Site Processing Small Area

OK

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MATLAB R2014a

HOME PLOTS APPS

Current Folder: /home/periz/SAR/matlab/pcodes

Processing the Coherence Map Generation

Using 8 workers

Coherence map processing started

file /data0/POLAND_MINES/RESULTS/MATLAB/MatrInc

One-Sensor STAR Images Graph

SITE PROCESSING - /data0/POLAND_MINES/

Current Images Graph: One-sensor STAR

Preliminary analysis:

- Reflectivity Map and Amplitude Stability Index: Go
- Mask for Sparse Points selection: Go

Preliminary geocoding:

- External DEM selection (Current: SRTM): Go
- DEM visualization: Go
- GCP selection: Go
- External DEM and synthetic amplitude in SAR coordinates: Go
- Coregistration Refinement (optional): Go

Sub-dataset extraction: Selection and Extraction: Go

Auxiliary analysis:

- Multi-Temporal Adaptive Mask: Go
- Change detection: Go
- Multi-Channel Change detection: Go
- Image classification: Go

InSAR processing:

- InSAR Params: Go
- Reset flat/height constants: Go
- Full Graph Coherence estimation: Go
- Residual fringes estimation and removal: Go
- Interferograms processing: Go
- Coherence Map generation: Go
- Single Interferogram processing: Go

Sparse points selection:

- Load Mask: Go
- Custom Mask Generation: Go

Amplitude processing:

- Images fine equalization: Go
- Amplitude time series analysis: Go
- Sub-pixel positions analysis: Go

Multi Image InSAR processing:

- APS estimation: Go
- Graph Analysis and Refinement: Go
- Sparse Points processing: Go

Post-analysis:

- Geografic Corrections: Go
- DEM post-analysis: Go
- PS classification: Go
- Time Series Module: Go
- Multi-sensor analysis: Go

Visualization/Export tools:

- Histograms: Go
- Scatter Plots: Go
- Sparse Data Export (kml-csv): Go
- View/Export Extended Data/Results: Go

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NO security prompt

Running in Normal Mode

Refresh OK

1. We click on "coherence map generation" to calculate the average coherence of the dataset

Note: in this dataset we have 1 single interferogram. So, this operation is not meaningful. However, in this way we generate the "coherence map" (in our case it corresponds to the coherence of our interferogram): we will use this parameter later on.

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MAIN - /data0/POLAND_MINES/

Current Images Graph: One-sensor STAR

Auxiliary analysis: Multi-Temporal Adaptive Mask, Change detection

Preliminary analysis: Reflectivity Map, Amplitude Stability

Mask for Sparse Points selection

Preliminary generation

External DEM: Current: S

DEM visualization

GCP selection

External DEM: Conversion: none, Mask: none, Thres: 0, APS Removal: ☐

Coregistration Refinement (optional)

Sub-dataset selection

Export in GEOGRAPHIC coordinates: Mode: Geocode, File type: Kml, Rg: 1, Az: 1

View/Export in SAR coordinates: Plot, jpg/Png, OK

Options: Saturation: Auto, Min, Max

Zero Reference: none, Lat, Lon

InSAR processing: PS estimation, Graph Analysis and Refinement, Sparse Points processing

Post-analysis: Geographic Corrections, DEM post-analysis, PS classification, Time Series Module, Multi-sensor analysis

Visualization/Export tools: Histograms, Scatter Plots, Sparse Data Export (kml-csv), View/Export Extended Data/Results

Running in Normal Mode

Refresh, OK

MATLAB R2014a

HOME, PLOTS, APPS

Processing the Coherence Map Generation

Using 8 workers

Coherence map processing started

file /data0/POLAND_MINES/RESULTS/MATLAB/MatInc

One-Sensor STAR Images Graph

save_coher_map: one single interferogram detected! copying

save_coher_map: Ampl. Stab Index plus Spatial Coherence is

The Processing concluded successfully, here a specific message.

Coherence Map Generation

Elapsed Time: 2 seconds

12-Apr-2019 11:27:13

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1. To plot the multi-looked interferogram, we use again the "view/export extended data/results" module

2. And we choose the "single interferogram" mode

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MAIN - /data0/POLAND_MINES/

Select Dataset Dataset D

Site Processing Small Area

OK

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MATLAB R2014a

HOME PLOTS APPS

Processing the coherence map Generation

Using 8 workers

Coherence map processing started

file /data0/POLAND_MINES/RESULTS/MATLAB/MatrInc

One-Sensor STAR Images Graph

save_coher_map: one single interferogram detected! copying its coherence to the coherence map!!

save_coher_map: Ampl. Stab Index plus Spat

The Processing concluded successfully, her

Coherence Map Generation : job ended

Elapsed Time: 2 seconds

12-Apr-2019 11:27:13

fx >>

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SITE PROCESSING - /data0/POLAND_MINES/

Current Images Graph One-sensor STAR

Auxiliary analysis Multi-Temporal Adaptive Mask Go Change detection Go

Preliminary analysis Reflectivity M Amplitude Sta Mask for Sp Points sele Preliminary ge External DEM Current: S DEM visuali GCP sele External DE synthetic am in SAR coord Coregistr Refinem (option Sub-dataset e Selection Extract

PLOT PARAMETERS - /data0/POLAND_MINES/

Data to Plot Mode Single Interferogram Interferogram Coher/Phase Options Saturation Auto Zero Reference none Lat Lon InSAR Conversion: none Mask: none Thres. 0 APS Remo... Output: Auto Export in GEOGRAPHIC coordinates Mode Geocode File type Kml Rg 1 Az 1 Export View/Export in SAR coordinates Plot Jpg/Png OK

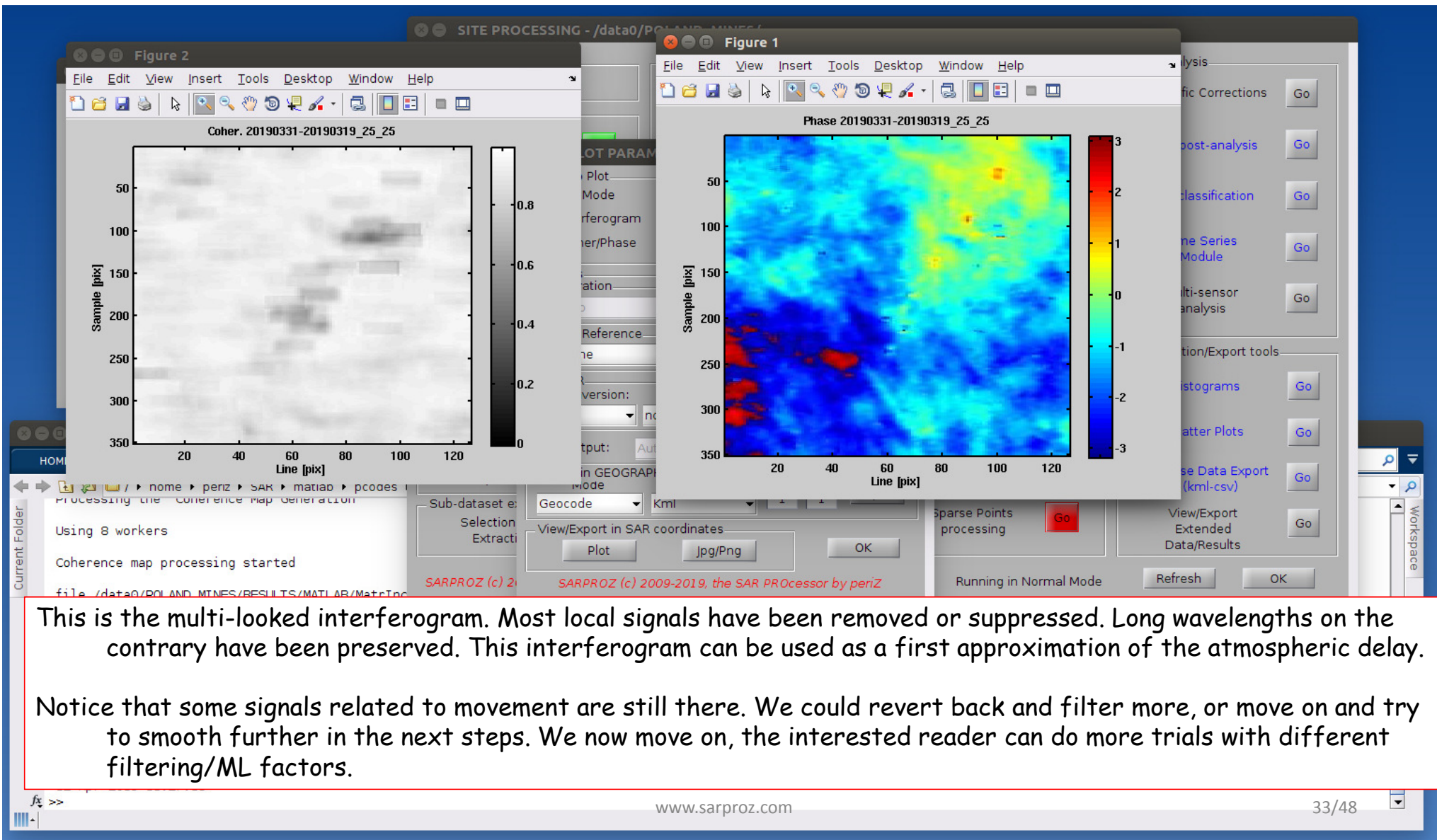
20190319-20190319
20190319-20190319_25_25
20190331-20190319
20190331-20190319_25_25

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1. This time we pick up the multi-looked interferogram: notice the 25*25 ML factor

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The image displays the SARPROZ software interface, which is a MATLAB-based application for SAR data processing. The main window, titled 'MAIN - /data0/POLAND_MINES/', shows the 'SARPROZ' logo and a 'Select Dataset' button. A 'SITE PROCESSING' window is open, showing a grid of processing modules. The 'Multi-looked interferogram' module is highlighted with a red circle. The MATLAB R2014a command window shows the execution of the 'Coherence Map Generation' module, with the following output:

```
Processing the Coherence Map Generation
Using 8 workers
Coherence map processing started
file /data0/POLAND_MINES/RESULTS/MATLAB/MatrInc
One-Sensor STAR Images Graph
```

The 'SITE PROCESSING' window includes the following modules:

- Current Images Graph: One-sensor STAR
- Preliminary analysis: Reflectivity Map and Amplitude Stability Index, Mask for Sparse Points selection
- Preliminary geocoding: External DEM selection, DEM visualization, GCP selection, External DEM and synthetic amplitude in SAR coordinates, Coregistration Refinement (optional)
- Sub-dataset extraction: Selection and Extraction
- Auxiliary analysis: Multi-Temporal Adaptive Mask, Change detection, Multi-Channel Change detection, Image classification
- InSAR processing: InSAR Params, Reset flat/height constants, Full Graph Coherence estimation, Residual fringes estimation and removal, Interferograms processing, Coherence Map generation, Single Interferogram processing
- Sparse points selection: Load Mask, Custom Mask Generation
- Amplitude processing: Images fine equalization, Amplitude time series analysis, Sub-pixel positions analysis
- Multi Image InSAR processing: APS estimation, Graph Analysis and Refinement, Sparse Points processing
- Post-analysis: Geographic Corrections, DEM post-analysis, PS classification, Time Series Module, Multi-sensor analysis
- Visualization/Export tools: Histograms, Scatter Plots, Sparse Data Export (kml-csv), View/Export Extended Data/Results

The status bar at the bottom of the 'SITE PROCESSING' window indicates 'SARPROZ (c) 2009-2019, the SAR PROcessor by periz', 'NO security prompt', and 'Running in Normal Mode'.

1. To use the multi-looked interferogram as input for atmospheric delay estimation, we use the corresponding module.

The Processing concluded successfully, here a specific message:

```
Coherence Map Generation : job ended
Elapsed Time: 2 seconds
12-Apr-2019 11:27:13
```

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SARPROZ
The SAR, InSAR, PSI, ... PROcessor, by periz

MAIN - /data0/POLAND_MINES/

Select Dataset Dataset D

Site Processing Small Area

OK

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MATLAB R2014a

HOME PLOTS APPS

Current Folder: /home/periz/SAR/matlab/pcodes

Processing the Coherence Map Generation

Using 8 workers

Coherence map processing started

file /data0/POLAND_MINES/RESULTS/MATLAB/MatrInc

One-Sensor STAR Images Graph

save_coner_map: Ampt. Stab Index plus Spatial Coherence is calculated

The Processing concluded successfully, here a specific message

Coherence Map Generation : job ended

Elapsed Time: 2 seconds

12-Apr-2019 11:27:13

SITE PROCESSING - /data0/POLAND_MINES/

Current Images Graph: One-sensor STAR

Auxiliary analysis: Multi-Temporal Adaptive Mask, Change detection

Sparse points selection: Load Mask

Post-analysis: Geographic Corrections

APS Processing - /data0/POLAND_MINES/

Images Combination: STAR, 1 sensor

Plot Graph Images Nr. 2 Conn. Nr. 2 Missing APS: 2 Update Mode APS pre-removal

Sparse Points Selection

Parameter Thresh. DS DL PSC Nr:

AzPos Master Mu AzPos Sigma AzPos PS type PS type weight Amp. Stab. Index 1-Sigma Synt. Coher. **Spatial Coher.** Ext. DEM Height Synthetic Amplitude Eff. Bn Eff. Bt Amp. Stab. Mu/Sigma Atmo. Coherence Life Time Cumulative Displacement Amp. Stab. Ind plus Sp. MT Adapt Mask Cluter N MT Adapt Mask Cluter S Choose a Real file

Min Nr Min R Max R

10 30 Inf

Go Plot Save Load

Connections processing

Go Save As Clear Diff Load

Connections coherence

Hist Plot Graph N Stats

Non-Linear Weighting

m p M

0 0.5 1

Plot

Reference Point

Auto Go Plot Nr 0 < >

S; L:

Estimated Parameters

R r0 ds Flatten Optional Optional

Plot 1 1 10 Save Export TS

APS options

Type Inverted Residu... Stratif R 150 DSF 25

APS Estimate

Test OK

1. We pick up the Spatial coherence as an index to select a sparse set of points

www.sarproz.com

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The screenshot displays the SARPROZ software interface, specifically the 'APS Processing' window. The window is titled 'APS Processing - /data0/POLAND_MINES/'. It contains several sections for configuring the processing parameters:

- Images Combination:** 'STAR, 1 sensor' is selected. 'Plot Graph' is a button. 'Images Nr.' is 2, 'Conn. Nr.' is 2, and 'Missing APS' is 2. 'Update Mode' and 'APS pre-removal' are radio buttons.
- Sparse Points Selection:** 'Parameter' is 'Spatial Coher.', 'Thresh.' is 0.8, 'DS' is 50, 'DL' is 0, and 'PSC Nr.' is 6861. A green 'Go' button is highlighted with a red circle.
- Graph Creation:** 'Delaunay' is selected. 'Min Nr' is 10, 'Min R' is 30, and 'Max R' is Inf. A red 'Go' button is highlighted with a red circle.
- Processing Parameters:** A table of parameters with radio buttons for 'Estimate', 'Read', and 'Neglect'.
- Connections processing:** 'Go', 'Save As', 'Clear Diff', and 'Load' buttons.
- Connections coherence:** 'Hist', 'Plot Graph', and 'N Stats' buttons.
- Reference Point:** 'Auto' is selected. 'Go', 'Plot', and 'Nr' buttons.
- Estimated Parameters:** 'Plot', 'R', 'r0', 'ds', 'Flatten', 'Optional', and 'Optional' buttons.
- APS options:** 'Type' is 'Inverted Residu...', 'Stratif' is checked, 'R' is 150, 'DSF' is 25.
- APS Estimate:** 'Go', 'Plot', 'Test', and 'OK' buttons.

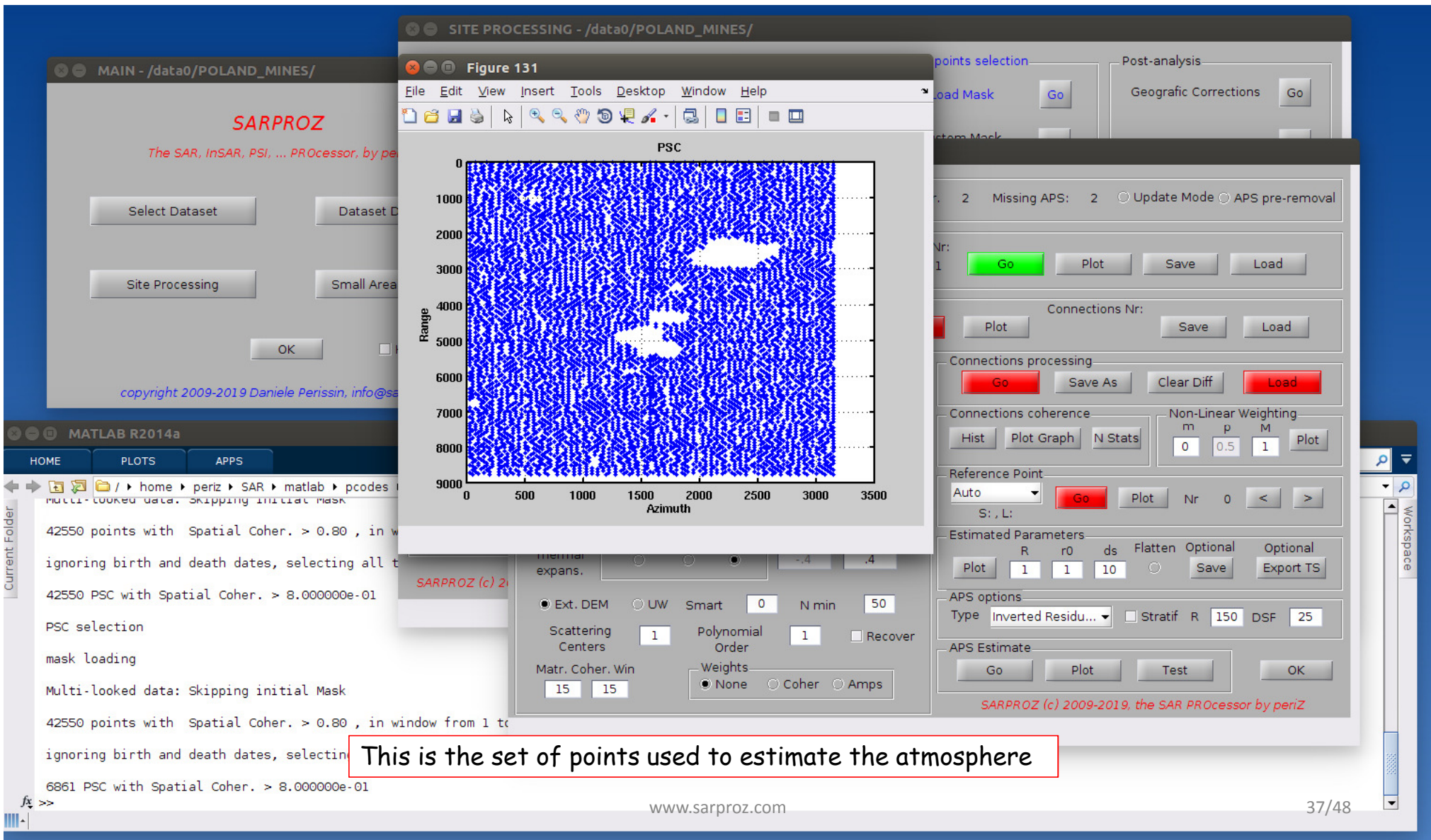
Annotations include red circles around the 'Go' button in the 'Sparse Points Selection' section and the 'Go' button in the 'Graph Creation' section. A red line connects the 'Go' button in the 'Sparse Points Selection' section to the 'Go' button in the 'Graph Creation' section. A red box highlights the 'Go' button in the 'Sparse Points Selection' section.

1. We set 0.8 as thresholds and DS=50 (this corresponds to an additional spatial smoothing. Increasing this number would increase the smoothing).

2. We press "go": 6861 points are extracted.

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MAIN - /data0/POLAND_MINES/

Select Dataset Dataset D

Site Processing Small Area

OK

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MATLAB R2014a

HOME PLOTS APPS

Current Folder: /home/periz/SAR/matlab/pcodes

ignoring birth and death dates, selecting all

42550 PSC with Spatial Coher. > 8.000000e-01

PSC selection

mask loading

Multi-looked data: Skipping initial Mask

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1. We press "go" in "graph creation" to generate the default "Delaunay" graph: 20357 connections are extracted.

6861 PSC with Spatial Coher. > 8.000000e-01

Delaunay Graph

connections number: 20357

SITE PROCESSING - /data0/POLAND_MINES/

Current Images Graph: One-sensor STAR

Auxiliary analysis: Multi-Temporal Adaptive Mask Go

Preliminary analysis: Change detection Go

Sparse points selection: Load Mask Go

Post-analysis: Geographic Corrections Go

APS Processing - /data0/POLAND_MINES/

Images Combination: STAR, 1 sensor Plot Graph Images Nr. 2 Conn. Nr. 2 Missing APS: 2 Update Mode APS pre-removal

Sparse Points Selection: Parameter: Spatial Coher. Thresh. .8 DS 50 DL 0 PSC Nr: 6861 Go Plot Save Load

Graph Creation: Delaunay Min Nr 10 Min R 30 Max R Inf Go Plot Connections Nr: 20357 Save Load

Processing Parameters:

	Estimate	Read	Neglect	Parameters Range
Linear Trend	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-100 100
Height	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-100 100
Azimuth Pos.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-1 1
Phase Shift	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-pi pi
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-.4 .4

Ext. DEM UW Smart 0 N min 50

Scattering Centers 1 Polynomial Order 1 Recover

Coher Amps

Connections processing: Go Save As Clear Diff Load

Connections coherence: Hist Plot Graph N Stats

Non-Linear Weighting: m 0 p 0.5 M 1 Plot

Reference Point: Auto Go Plot Nr 0 < >

S: , L:

Estimated Parameters: R 1 r0 1 ds 10 Flatten Optional Save Optional Export TS

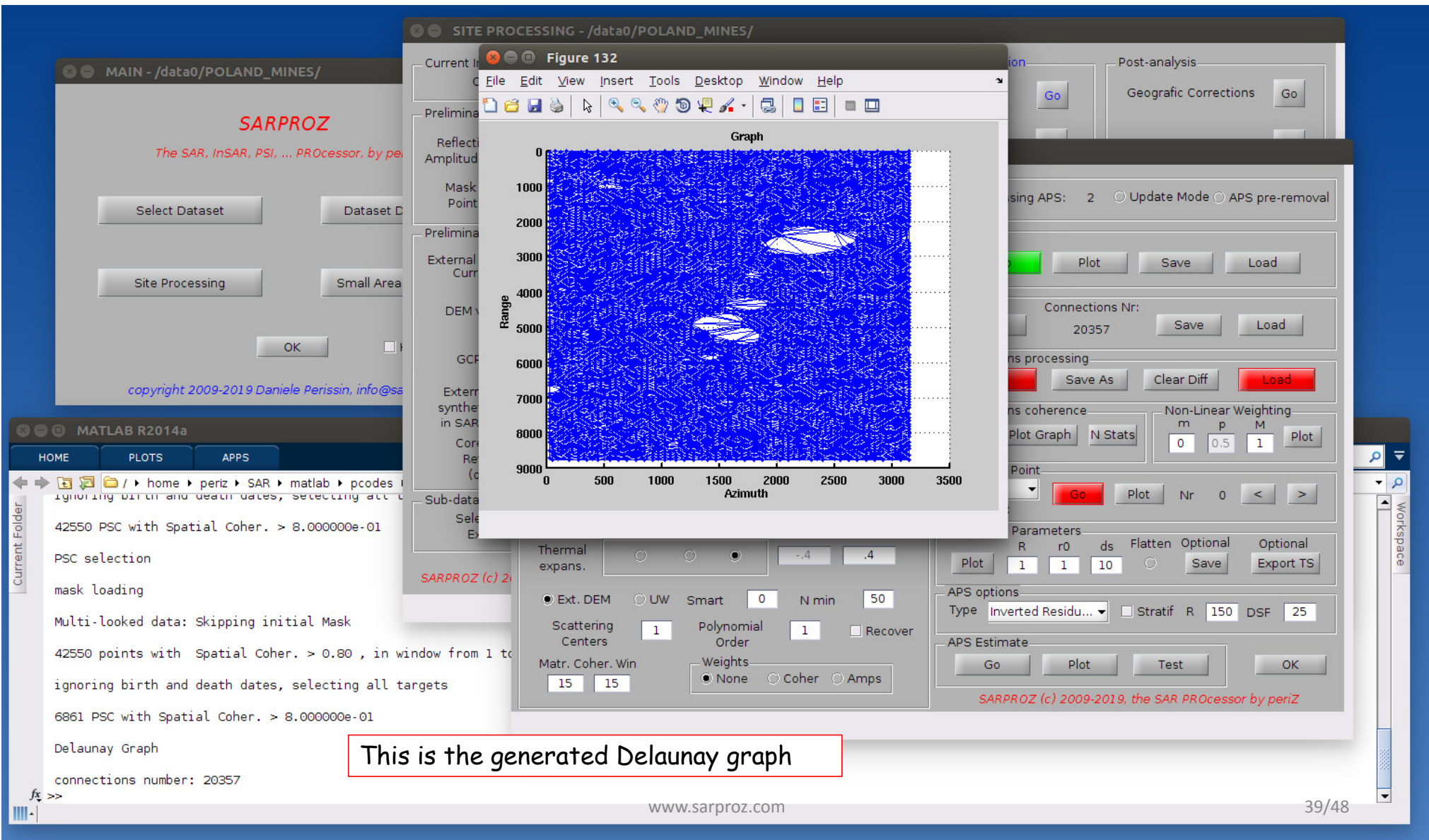
APS options: Type Inverted Residu... Stratif R 150 DSF 25

APS Estimate: Go Plot Test OK

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MAIN - /data0/POLAND_MINES/

SARPROZ

The SAR, InSAR, PSI, ... PROcessor, by periz

Select Dataset Dataset D

Site Processing Small Area

OK

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MATLAB R2014a

HOME PLOTS APPS

Current Folder

/home/periz/SAR/matlab/pcodes

42550 PSC with spatial Coher. > 8.000000e-01

PSC selection

mask loading

Multi-looked data: Skipping initial Mask

42550 points with Spatial Coher. > 0.80 , in Window from 1 to 1

ignoring birth and death dates, selecting all targets

6861 PSC with Spatial Coher. > 8.000000e-01

Delaunay Graph

SITE PROCESSING - /data0/POLAND_MINES/

Current Images Graph One-sensor STAR

Auxiliary analysis Multi-Temporal Adaptive Mask Go Change detection Go

Preliminary analysis Reflectivity M Amplitude Sta

Mask for Sp Points sele

Preliminary ge

External DEM Current: S

DEM visuali

GCP sele

External DE synthetic an in SAR coord

Coregistr Refinem (option

Sub-dataset e Selection Extract

APS Processing - /data0/POLAND_MINES/

Images Combination STAR, 1 sensor Plot Graph Images Nr. 2 Conn. Nr. 2 Missing APS: 2 Update Mode APS pre-removal

Sparse Points Selection Parameter Thresh. DS DL PSC Nr: Spatial Coher. .8 50 0 6861 Go Plot Save Load

Graph Creation Min Nr Min R Max R Connections Nr: Delaunay 10 30 Inf 20357 Go Plot Save Load

Processing Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-100	100
Height	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-100	100
Azimuth Pos.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-1	1
Phase Shift	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-pi	pi
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-.4	.4

☐ Ext. DEM ☐ UW Smart 0 N min 50

Scattering Centers 1 Polynomial Order 1 Recover

Matr. Coher. Win 15 15 Weights ☐ None ☒ Coher ☐ Amps

Connections processing Go Save As Clear Diff Load

Connections coherence Hist Plot Graph N Stats

Non-Linear Weighting m p M 0 0.5 1 Plot

Reference Point Auto Go Plot Nr 0 < >

S: , L:

Estimated Parameters R r0 ds Flatten Optional Optional Plot 1 1 10 Save Export TS

APS options Type Inverted Residu... Stratif R 150 DSF 25

APS Estimate Go Plot Test OK

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1. We tell the software to load the processed interferograms by selecting the coherence as weight. Notice that the sw will load the current InSAR settings, corresponding to multi-looked interferograms. Also, the set of used interferograms is the "STAR" graph.

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MAIN - /data0/POLAND_MINES/

SARPROZ
The SAR, InSAR, PSI, ... PROCessor, by periz

Select Dataset Dataset D
Site Processing Small Area
OK

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MATLAB R2014a

HOME PLOTS APPS

Current Folder
/home/periz/SAR/matlab/pcodes/processing (single scattering center, weighted)

too few images: skipping the master error correction
ignoring the reference error
The Processing concluded successfully, here a screenshot of the APS Graph processing concluded successfully
Elapsed Time: 4 seconds
12-Apr-2019 12:23:00
Simulating Noise Statistics

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SITE PROCESSING - /data0/POLAND_MINES/

Current Images Graph
One-sensor STAR

Auxiliary analysis
Multi-Temporal Adaptive Mask Go
Change detection Go

Sparse points selection
Load Mask Go
Custom Mask

Post-analysis
Geographic Corrections Go

APS Processing - /data0/POLAND_MINES/

Images Combination
Mask for Sparse Points selection: STAR, 1 sensor Plot Graph Images Nr. 2 Conn. Nr. 2 Missing APS: 2 Update Mode APS pre-removal

Preliminary analysis
Reflectivity Map Amplitude Statistics

Preliminary geodesy
External DEM Current: S

DEM visualization
GCP selection

Sparse Points Selection
Parameter: Spatial Coher. Thresh. .8 DS 50 DL 0 PSC Nr: 6861 Go Plot Save Load

Graph Creation
Delaunay Min Nr 10 Min R 30 Max R Inf Go Plot Connections Nr: 20357 Save Load

Processing Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-100	100
Height	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-100	100
Azimuth Pos.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-1	1
Phase Shift	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-pi	pi
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-.4	.4

☐ Ext. DEM ☐ UW Smart 0 N min 50

Scattering Centers 1 Polynomial Order 1 Recover

Matr. Coher. Win 15 15 Weights ☐ None ☒ Coher ☐ Amps

Connections processing
Go Save As Clear Diff Load

Connections coherence
Hist Plot Graph N Stats

Non-Linear Weighting
m 0 p 0.5 M 1 Plot

Reference Point
Auto Go Plot Nr 0 < >

S: , L:

Estimated Parameters
Plot R 1 r0 1 ds 10 Flatten Optional Save Optional Export TS

APS options
Type Inverted Residu... Stratif R 150 DSF 25

APS Estimate
Go Plot Test OK

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1. We press the button "go" to process the connections. Notice that here we are NOT estimating either topography or movement. Our assumption is that the only signal in the interferogram is atmosphere. To estimate height and/or movement we would need more interferograms

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MAIN - /data0/POLAND_MINES/

Select Dataset Dataset D

Site Processing Small Area

OK

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APPS Processing - /data0/POLAND_MINES/

Current Images Graph: One-sensor STAR

Auxiliary analysis: Multi-Temporal Adaptive Mask (Go), Change detection (Go)

Sparse points selection: Load Mask (Go), Custom Mask

Post-analysis: Geographic Corrections (Go)

Preliminary analysis: Reflectivity M, Amplitude Sta

Mask for Sparse Points selection

Preliminary ge: External DEM, Current: S

DEM visual: GCP sele

External DE: synthetic an in SAR coord

Coregistr: Refinem (option

Sub-dataset e: Selection, Extract

Images Combination

STAR, 1 sensor Plot Graph Images Nr. 2 Conn. Nr. 2 Missing APS: 2 Update Mode APS pre-removal

Sparse Points Selection

Parameter: Spatial Coher. Thresh. .8 DS 50 DL 0 PSC Nr: 6861 Go Plot Save Load

Graph Creation

Delaunay Min Nr 10 Min R 30 Max R Inf Go Plot Connections Nr: 20357 Save Load

Processing Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-100	100
Height	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-100	100
Azimuth Pos.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-1	1
Phase Shift	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-pi	pi
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-.4	.4

☐ Ext. DEM ☐ UW Smart 0 N min 50

Scattering Centers 1 Polynomial Order 1 Recover

Matr. Coher. Win 15 15 Weights ☐ None ☒ Coher ☐ Amps

Connections processing

Go Save As Clear Diff Load

Connections coherence

Hist Plot Graph N Stats

Non-Linear Weighting

m p M Plot 0 0.5 1

Reference Point

Auto Go Plot Nr 1 < >

S: 4200, L: 1500

Estimated Parameters

Plot R 1 r0 1 ds 10 Flatten Optional Optional Save Export TS

APS options

Type Inverted Residu... Strat R 50 DS 25

APS Estimate

Go Plot Test OK

1. We select a reference point by pressing "go"

2. We set the filtering Radius = 50. We think we have filtered enough...

3. Finally we estimate the APS

weighting the inversion of the graph connection
pcg converged at iteration 3 to a solution with
pcg converged at iteration 3 to a solution with relative residu
calculating nodes coherence
Ref Point Nr 1 out of 25
selected reference S: 4200 L: 1500, Temp Coher: 1.00, Sp Coher: 0.92

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The SAR, InSAR, PSI, ... PROCESSOR, Etc.

MAIN - /data0/POLAND_MINES/

Select Dataset Data

Site Processing Small

OK

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SITE PROCESSING - /data0/POLAND_MINES/

Current Images Graph
One-sensor STAR

Auxiliary analysis
Multi-Temporal Adaptive Mask Go

Sparse points selection
Load Mask Go

Post-analysis
Geographic Corrections Go
DEM post-analysis Go
PS classification Go
Time Series Module Go
Multi-sensor analysis Go

Preliminary analysis
Reflectivity Map and Amplitude Stability Index

Preliminary geocoding
External DEM selection Current: SRTM

DEM visualization
GCP selection

External DEM and synthetic amplitude in SAR coordinates

Coregistration Refinement (optional)

Sub-dataset extraction Selection and Extraction

PLOT PARAMETERS - /data0/POLAND_MINES/

Data to Plot
Mode: Single Interferogram
Interferogram:
Coher/Phase:
Options: Saturation: Auto

Zero Reference: none Lat: Lon:

InSAR Conversion: none Mask: none Thres: 0 ☐ APS Remo...

Output: Auto ☐ Colorbar Rev...

Export in GEOGRAPHIC coordinates
Mode: Geocode File type: Kml Rg: 1 Az: 1 Export

View/Export in SAR coordinates
Plot Jpg/Png OK

1. Now we want to plot again the full-resolution interferogram (no multi-looking)

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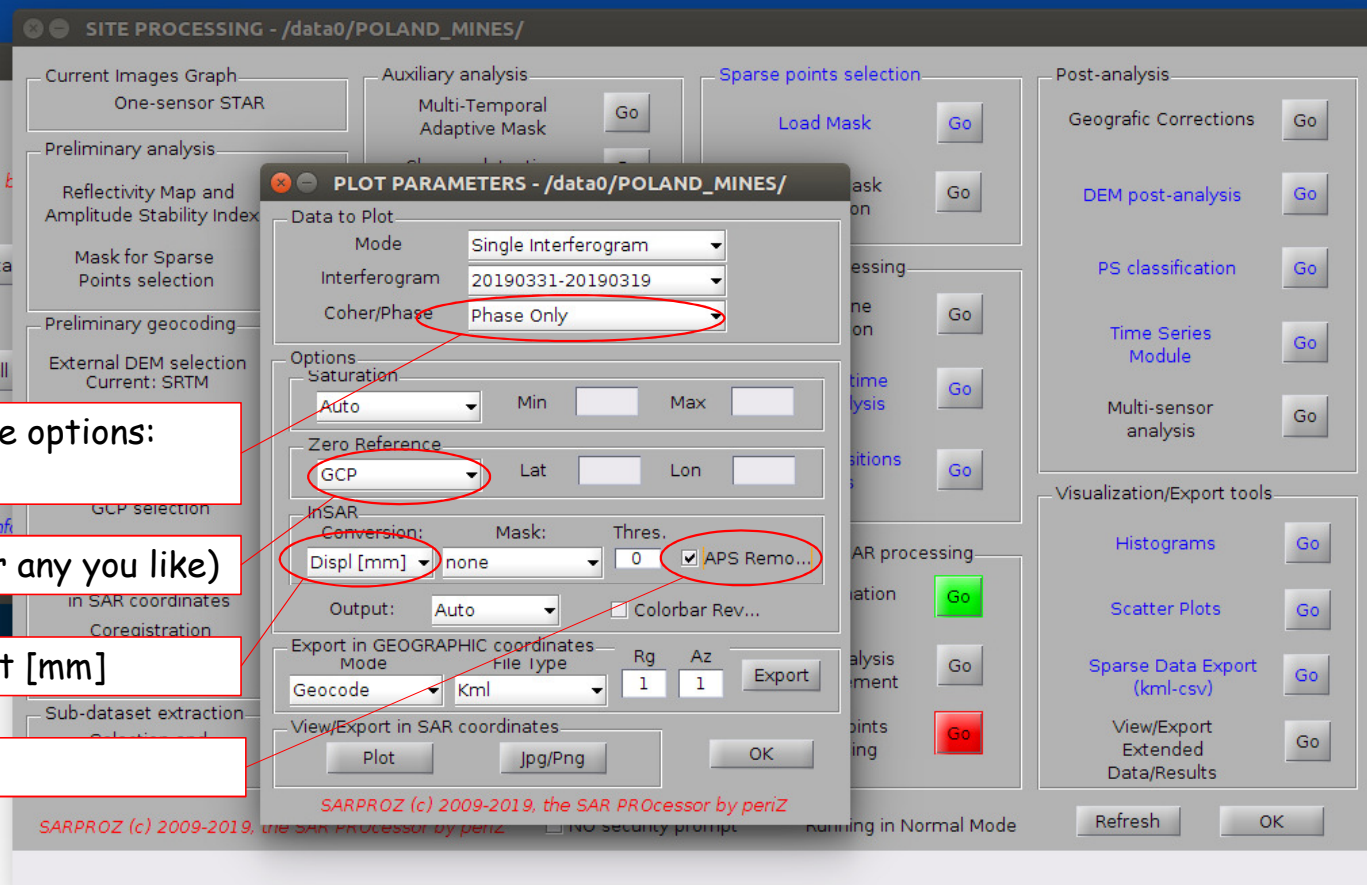
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1. This time we select more options:
phase only

2. Reference point: GCP (or any you like)

3. Conversion: Displacement [mm]

4. APS removal



SARPROZ
The SAR, InSAR, PS

MAIN - /data0/POLAND_MINES/

Current Images Graph
One-sensor STAR

Auxiliary analysis
Multi-Temporal Adaptive Mask

Sparse points selection
Load Mask

Post-analysis
Geographic Corrections

Figure 1
Displ. [mm] from Phase 20190331-20190319

Sample [pix]
1000
2000
3000
4000
5000
6000
7000
8000

Line [pix]
500 1000 1500 2000 2500 3000

12
6
0
-6
-12

Plot Parameters - /data0/POLAND_MINES/

Data to Plot
Mode: Single Interferogram
Interferogram: 20190331-20190319
Coher/Phase: Phase Only

Options
Saturation: Auto
Zero Reference: GCP
InSAR Conversion: Displ [mm]
Mask: none
Thres.: 0
APS Remo...
Output: Auto
Colorbar Rev...

Export in GEOGRAPHIC coordinates
Mode: Geocode
File type: Kml
Rg: 1
Az: 1
Export

View/Export in SAR coordinates
Plot
Jpg/Png
OK

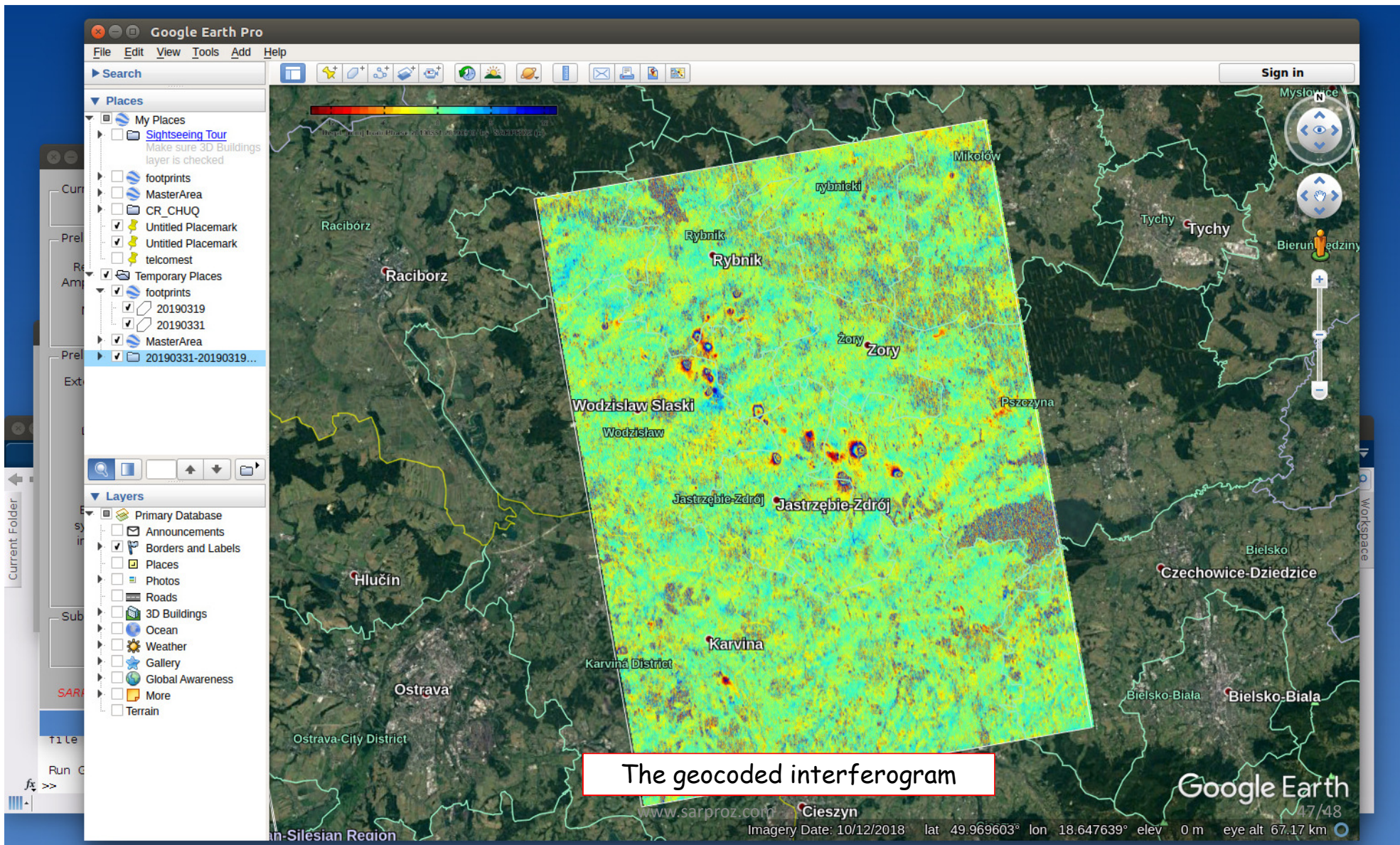
1. Then we plot it

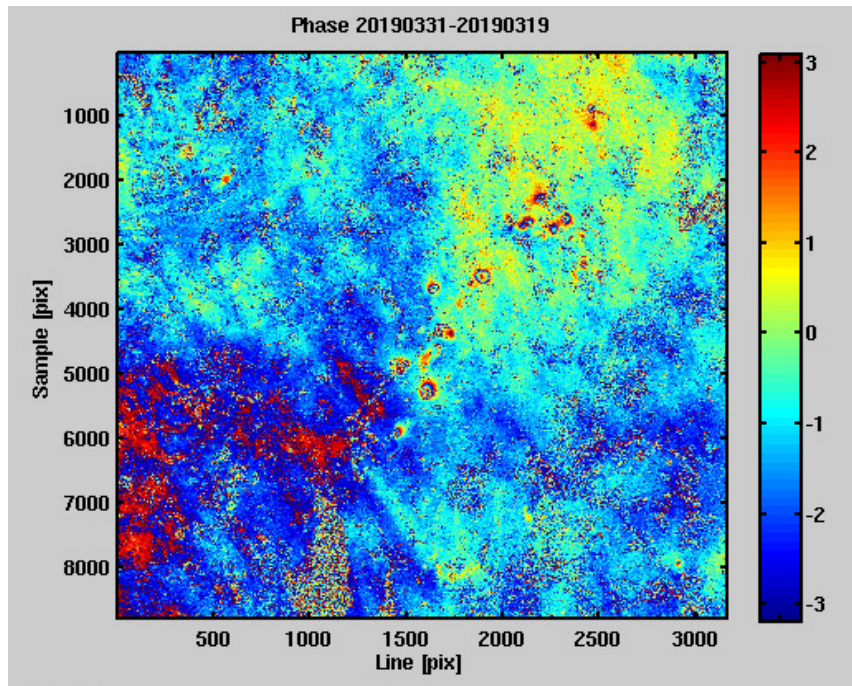
This is the result: now we have removed the long wavelengths and the local movements are more evident. Note that the atmospheric turbulence is still there. Nevertheless, now it's easier to read the signals.

2. And finally we geocode it →

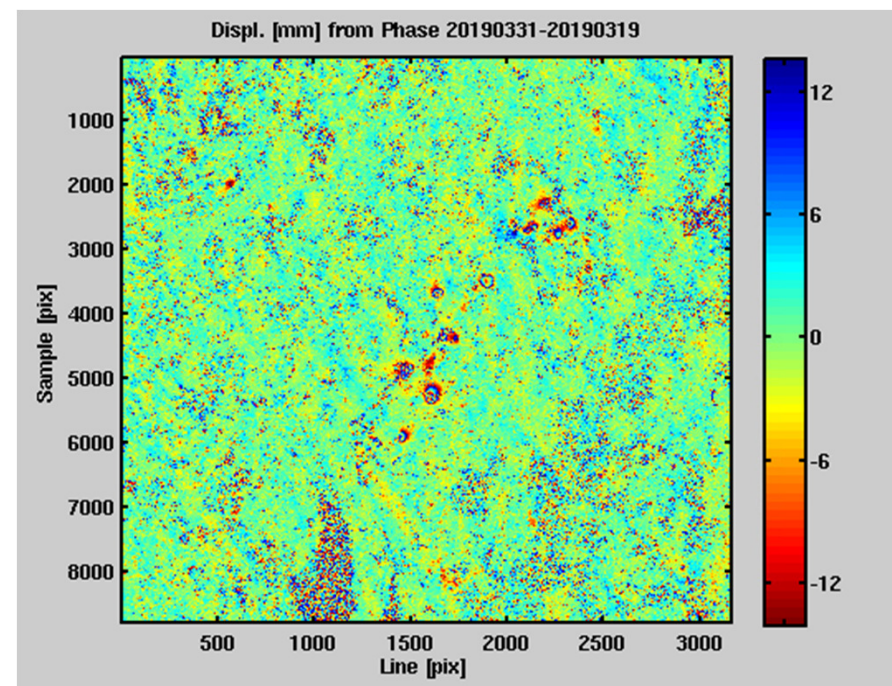
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Before



After

Note: in this exercise we have removed some signals and left others. We removed long (spatial) wavelengths and we left short ones. Under the assumption that long wavelengths are atmospheric delay and short ones are subsidence, we have improved signal readability. However, you have to make sure the assumption is correct in your case study. If you have multiple images, use common time series analysis to estimate movement and topography. The time series approach is more robust. Use the technique described here only when you have few coherent images.