

Demo: APS Estimation & Multi-temporal analysis with Sarproz

Sarproz processing tutorial series

By [Yuxiao QIN](#)

APS Estimation & Multi-temporal Analysis

In this tutorial, a demo is shown for estimating the atmospheric phase screen (APS) and doing InSAR time series analysis.

Downloading Sample Data

- ~~ftp://johndoe:psinsar12138@128.46.174.159/data/LA_small.tar.gz~~ SEE BELOW
 - File size: 532MB

THE LINK ABOVE IS NO LONGER WORKING

PLEASE USE THE FOLLOWING ONE

<https://my.pcloud.com/publink/show?code=XZjDnU7ZBjVOXMsDFc542fUWO0vBdLaq1TaV>

Part 1: Preparation

Step 0: start Sarproz

This is the main interface of Sarproz. We import our data by clicking “select dataset”, and then all the process are done in “site processing” module. You can also click “dataset description” to learn descriptions about your site.



Step 1-1: unpack and load data

Unpack the `LA_small.tar.gz` to your local folder with any extraction tool. You should have a “`LA_small`” folder after extraction.

Click “select dataset” in the main interface to open the module. Click “select” in “site directory” frame and select the “`LA_small`” folder. When the data is loaded, you should be able to see some basic information, such as samples, lines, number of images, sensors, etc.

DATASET SELECTION - /data2/LA_small/

Site Directory:

Data Set

Samples	1500	Lines	700	Images Nr	64
Primary	TanDEM-X	Secondary	-----		

Master and Images Selection

Master	Bn	DC	BtIn	BtFin
20120921 0 0.00 0 5 2...	3500	0.5	-Inf	Inf

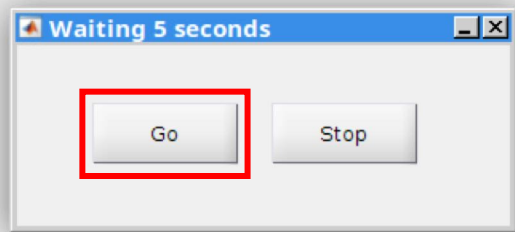
Images Graph

STAR, 1 sensor	0.5	Cohes Thres	Save As	Plot Graph
----------------	-----	-------------	---------	------------

Current Selection

Nr of Selected Images:	64	Nr of Connections:	64
------------------------	----	--------------------	----

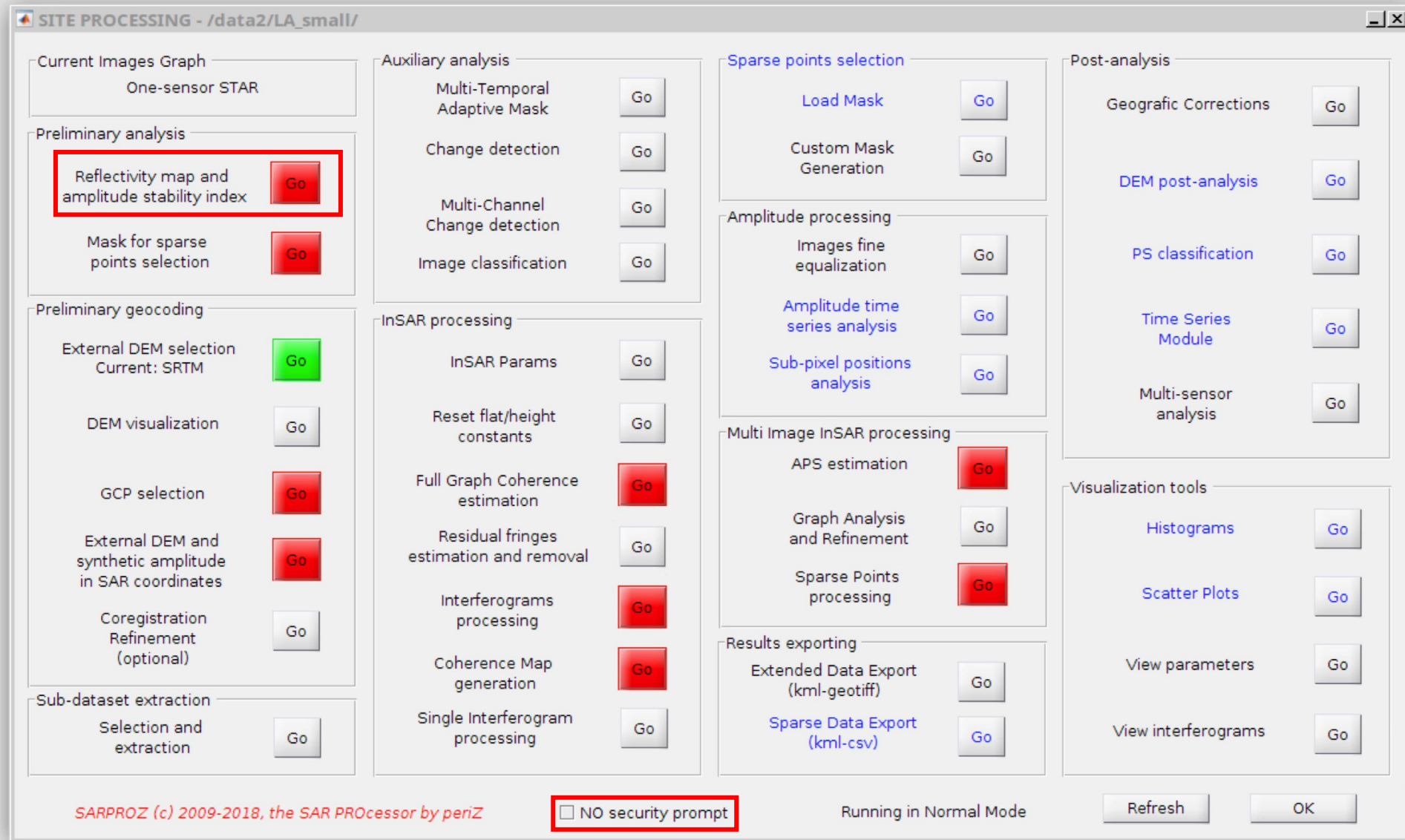
SARPROZ (c) 2009-2018, the SAR PROcessor by periz

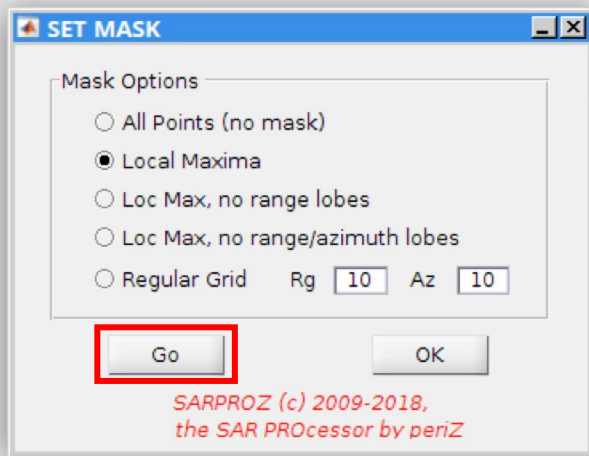


Step 1-2: reflectivity map

Open the “site processing” module. Click “Reflectivity map and amplitude stability index”. A prompt window “waiting 5 seconds...” will pop up for confirmation. Click “go” to confirm. When finished, the red button will turn green.

If you want to skip the prompt window, check the “No security prompt”.





Step 1-3: mask

Click “mask for sparse points selection”. In the “set mask” window, click “go” with the default option. When finished, click “ok” to close the window.

Check [here](#) and [here](#) to see more details about these processing steps.



Step 1-4: ground control point

Click and open “GCP selection” module. Put down the latitude/longitude and sample/line coordinate as shown in this slide. Click “write” to set the ground control point (GCP). When finished, you should see the message, “lat-lon coordinates written” in the command window. Then click “ok” to close the module.

For a more detailed description about how to select a GCP, please refer to [this tutorial](#).

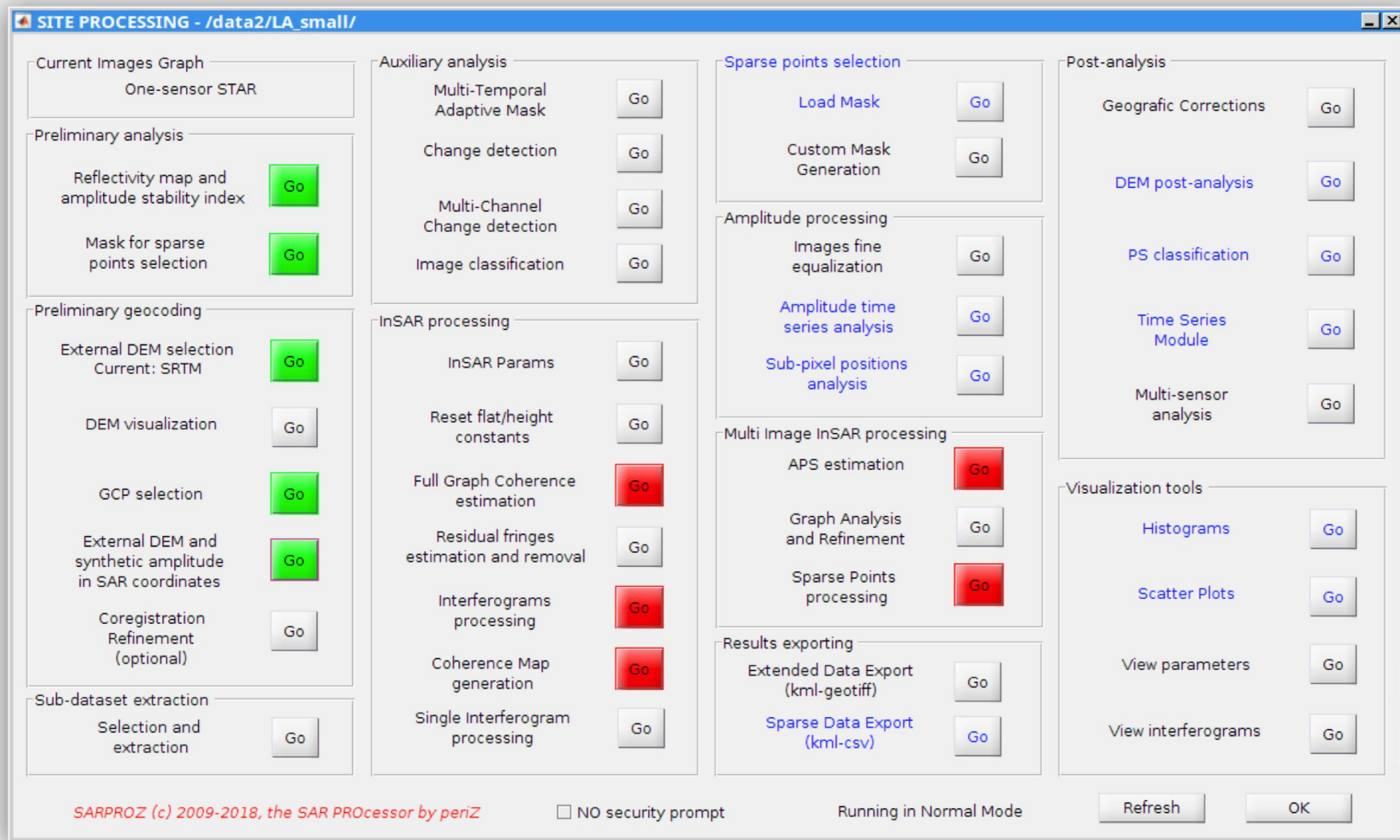
The screenshot shows the 'GCP - /data2/LA_small/' window. A red box highlights the 'GCP Coordinates' section, which contains input fields for North [m] / Lat [°] (34.036161), East [m] / Lon [°] (-118.309758), Ext. DEM Height (68), Sample (962), and Line (578). To the right, the 'Coord' section has radio buttons for 'Geo' (selected), 'UTM', and 'Local'. Below these are 'Zone' (11) and 'Hemi.' (North) dropdowns. The 'Pixel Selection' section has radio buttons for 'Adjust to Radar Target' (selected) and 'Force my pixel'. At the bottom of this section are 'Reset GCP & Orbits' and 'Write' buttons, with 'Write' highlighted by a red box. The 'Auto GCP' section has 'Keep Current Orbits' and 'Through Ext. DEM' buttons. The 'GCP Plot' section has 'Plot Mean', 'GCP Kml', 'Mean Kml' buttons, and a checked 'OVR' checkbox. At the bottom right, an 'Ok' button is highlighted by a red box. The footer text reads 'SARPROZ (c) 2009-2018, the SAR PROCESSOR by periz'.

The screenshot shows the MATLAB R2016a command window. The 'Current Folder' is '/data2/LA_small/RESULTS/'. The command window displays the following output:

```
/data2/LA_small/RESULTS/Lat.mat  
  
scrivi: file /data2/LA_small/RESULTS/Lon not  
found, writing sparse file  
/data2/LA_small/RESULTS/Lon.mat  
  
lat-lon coordinates written  
  
File /data2/LA_small/InputParFile.txt correctly  
updated  
fx >> |
```


Step 1-5: External DEM

Click “external DEM and synthetic amplitude in SAR coordinates”. When finished the button will turn green. We are now finished with pre processing step and can start the APS estimation.



Part 2:

APS Estimation

Step 2-1: open APS module

Click “APS estimation” from “site processing” panel.

APS Processing - /data2/LA_small/

Images Combination
STAR, 1 sensor Images Nr. 64 Conn. Nr. 64 Missing APS: 64 ☐ Update Mode ☐ APS pre-removal

Sparse Points Selection
Parameter Thresh. DS 20 DL 0 PSC Nr:

Graph Creation
Delaunay Connections Nr:

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 Gen 50

Scattering Centers 1 Polynomial Order 1 ☐ Recover

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

Connections processing

Connections coherence

Non-Linear Weighting
m 0 p 0.5 M 1

Reference Point
Auto Nr 0 < >
S: , L:

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

APS options
Type Inverted Residuals ☐ Stratif. R 150 DSF 25

APS Estimate

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Step 2-2: select points

Sparse point selection. Choose “amplitude stability index (Amp. Stab. Index 1-sigma/mu)” from the “parameter” dropdown menu. Put down “0.85” as the selection threshold. Keep the default down-sample (DS) and down-line (DL) value. DL is zero means it is using the same DS value of 20. Click “go” to select points. You can also plot, save and later load your selected points.

The screenshot shows the APS Processing software interface with the following sections and settings:

- Images Combination:** STAR, 1 sensor. Plot Graph. Images Nr. 64. Conn. Nr. 64. Missing APS: 64. Update Mode (unchecked). APS pre-removal (unchecked).
- Sparse Points Selection:** Parameter: Amp. Stab. Index 1-Sigm... (highlighted in red). Thresh.: .85 (highlighted in red). DS: 20. DL: 0. PSC Nr.: 502. Go (highlighted in red). Plot. Save. Load.
- Graph Creation:** Delaunay. Min Nr: 10. Min R: 30. Max R: Inf. Go (red). Plot. Connections Nr.: 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 (checked), UW (unchecked), Smart 0, N min Gen 50, Scattering Centers 1, Polynomial Order 1, Recover (unchecked), Matr. Coher. Win 15 15, Weights: None (checked), Coher (unchecked), Amps (unchecked).
- Connections processing:** Go (red), Save As, Clear Diff, Load (red).
- Connections coherence:** Hist, Plot Graph, N Stats. Non-Linear Weighting: m 0, p 0.5, M 1, Plot.
- Reference Point:** Auto (dropdown), Go (red), Plot, Nr 0, <, >.
- Estimated Parameters:** Plot, R 1, r0 1, ds 10, Flatten (unchecked), Optional Save, Optional Export TS.
- APS options:** Type Inverted Residuals (dropdown), Stratif. (unchecked), R 150, DSF 25.
- APS Estimate:** Go, Plot, Test, OK.

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Step 2-3: create graph

Create connection graph. Use the default Delaunay graph. Click “go” to generate the graph. You can also plot, save and later load your graph.

APS Processing - /data2/LA_small/

Images Combination
STAR, 1 sensor Plot Graph Images Nr. 64 Conn. Nr. 64 Missing APS: 64 ☐ Update Mode ☐ APS pre-removal

Sparse Points Selection
Parameter Thresh. DS DL PSC Nr:
Amp. Stab. Index 1-Sigm... .85 20 0 502 Go Plot Save Load

Graph Creation
Delaunay Min Nr 10 Min R 30 Max R Inf Go Plot Connections Nr: 1488 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 Gen 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

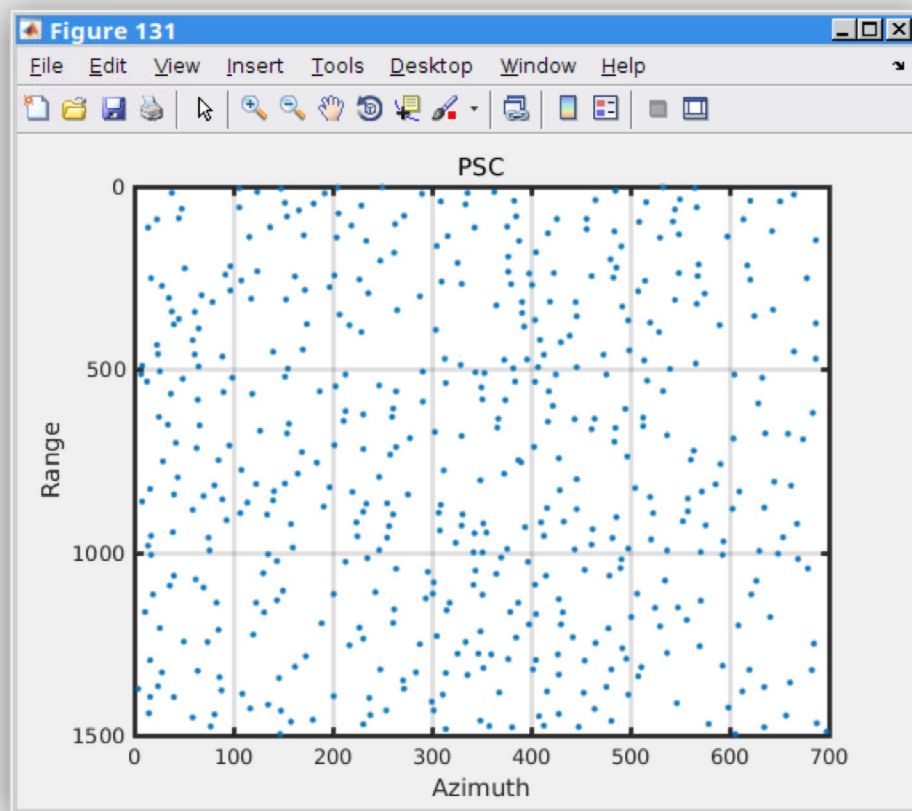
Reference Point
Auto Go Plot Nr 0 < >
S: , L:

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

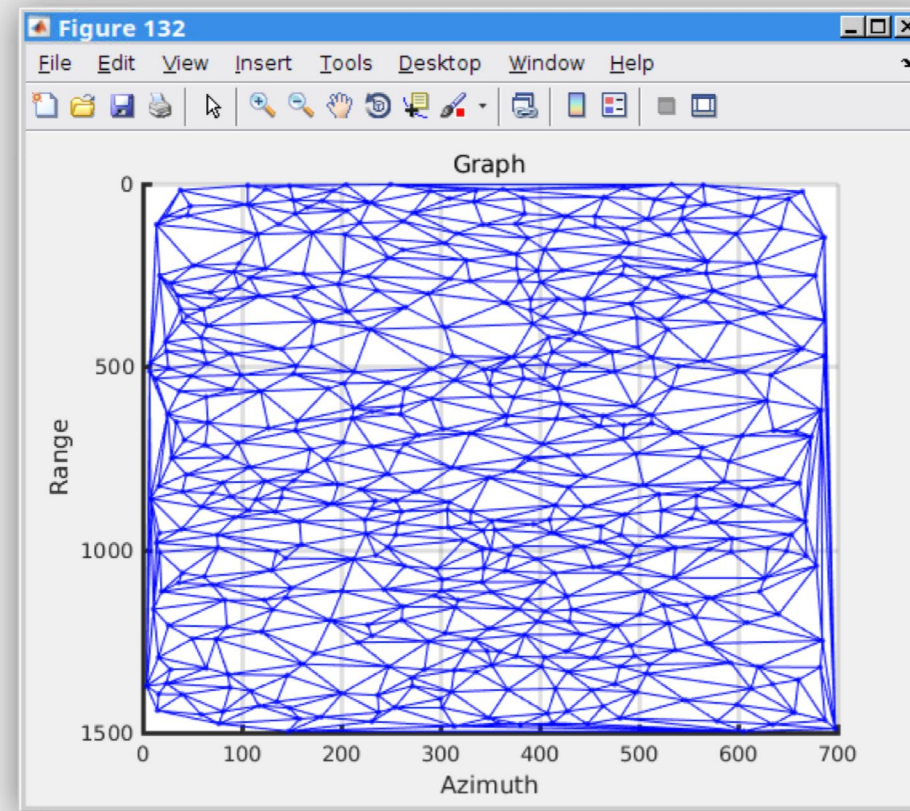
APS options
Type Inverted Residuals ☐ Stratif. R 150 DSF 25

APS Estimate
Go Plot Test OK

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The plot of sparse point selection



The plot of Delaunay graph connection

Step 2-4: estimate parameters

Put down ranges value for estimated parameters. Here we estimate linear trend and height and neglect other parameters. Put down “5” (millimeters/year) for linear trend and “20” (meters) for height. Make sure the external DEM is selected. Keep other options as in their default settings. Click “go” in “connections processing” to estimate the parameters in your connected graph.

The screenshot shows the APS Processing software interface with the following panels and settings:

- Images Combination:** STAR, 1 sensor. Plot Graph. Images Nr. 64. Conn. Nr. 64. Missing APS: 64. Update Mode (unchecked). APS pre-removal (unchecked).
- Sparse Points Selection:** Parameter: Amp. Stab. Index 1-Sigm... Thresh. .85. DS 20. DL 0. PSC Nr: 502. Go (green button). Plot. Save. Load.
- Graph Creation:** Delaunay. Min Nr 10. Min R 30. Max R Inf. Go (green button). Plot. Connections Nr: 1488. Save. Load.
- Processing Parameters:**

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-5	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-20	20
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

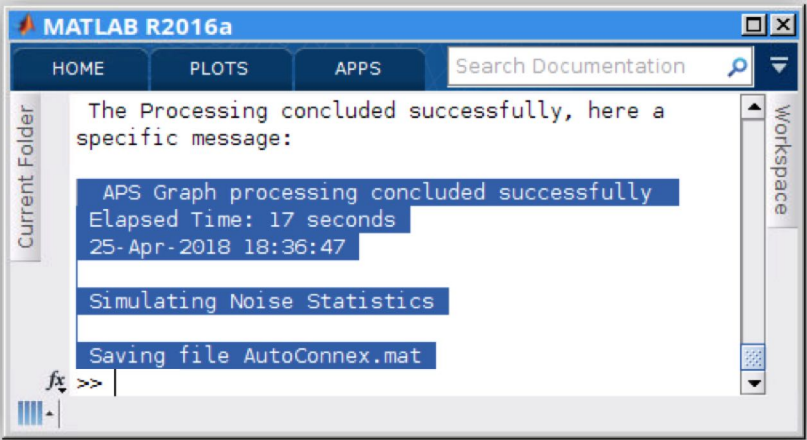
Ext. DEM (selected and highlighted with a red box). UW (unchecked). Smart 0. N min Gen 50. Scattering Centers 1. Polynomial Order 1. Recover (unchecked). Matr. Coher. Win 15 15. Weights: None (selected), Coher (unchecked), Amps (unchecked).
- Connections processing:** Go (red button). Save As. Clear Diff. Load (red button).
- Connections coherence:** Hist. Plot Graph. N Stats.
- Non-Linear Weighting:** m 0. p 0.5. M 1. Plot.
- Reference Point:** Auto. Go (red button). Plot. Nr 0. < >.
- Estimated Parameters:** R 1. r0 1. ds 10. Flatten (unchecked). Optional Save. Optional Export TS.
- APS options:** Type Inverted Residuals. Stratif. (unchecked). R 150. DSF 25.
- APS Estimate:** Go. Plot. Test. OK.

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Runtime: 8s - ETA: 5.44s
Graph Processing
59%

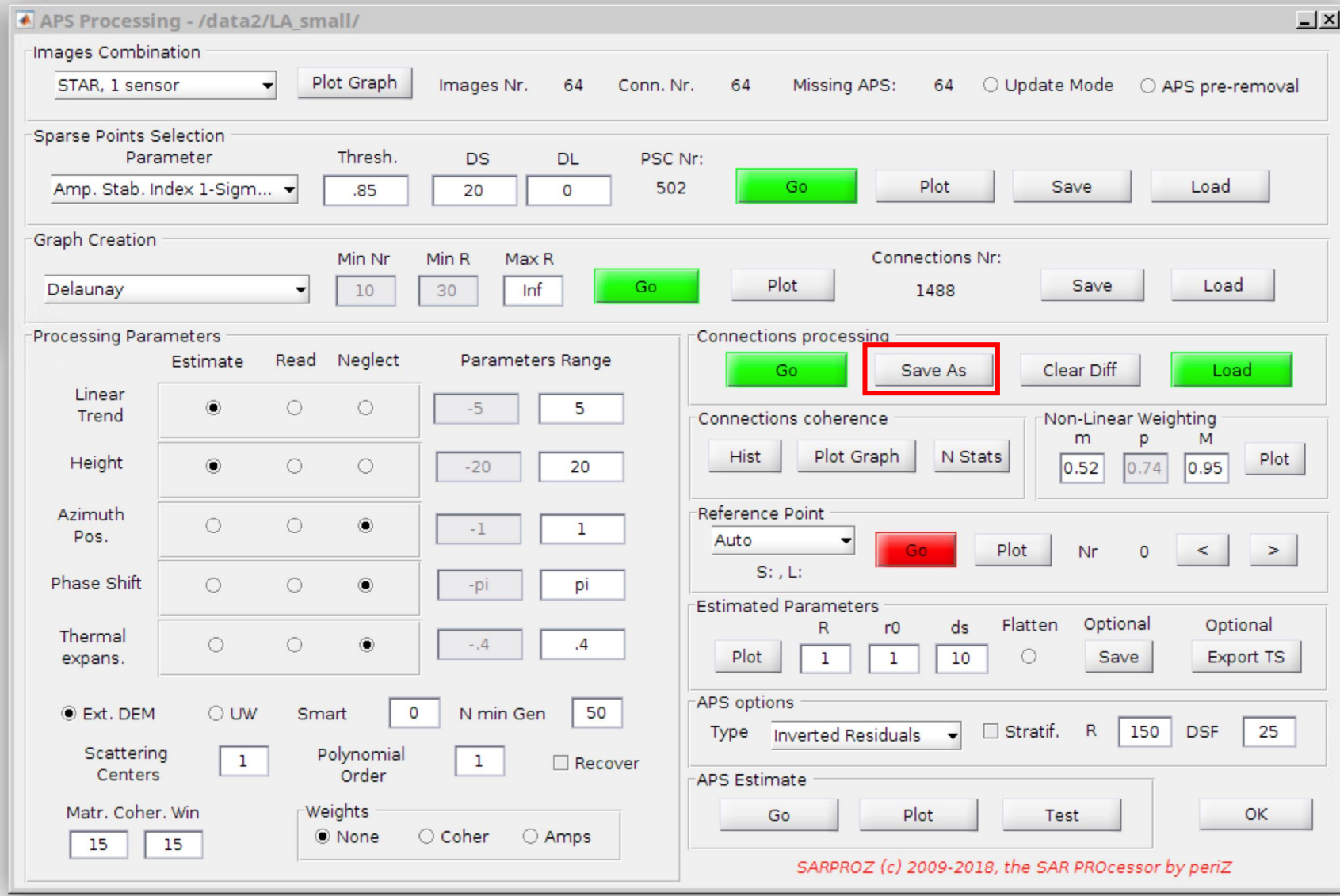
How to select the range for estimation?

- Later, in step 2-10, check the histogram of connection velocity and connection residual height. The histogram gives an idea of the velocity/residual height value distribution.
- If the numbers you put down in the first place are too large/too small, they would be reflected to the histogram. You can adjust your numbers accordingly and process again.



Step 2-5: connections process

A message “APS graph processing concluded successfully” will appear in command window when the process finishes. The result is automatically saved as “AutoConnex.mat”. You can also click “save as” to save it with your own filename. Later you can load your processed result with the “load” button in “connections processing” frame.



Step 2-6: connection coherence

It is important to check the connections coherence via the “hist” (histogram) and “plot graph” button. The histogram gives a statistical overview of coherence. The graph is useful for checking if there are isolated areas (with very low coherence to the rest of points). It is desired to be able to find a path to every points in the graph with high connection coherence value.

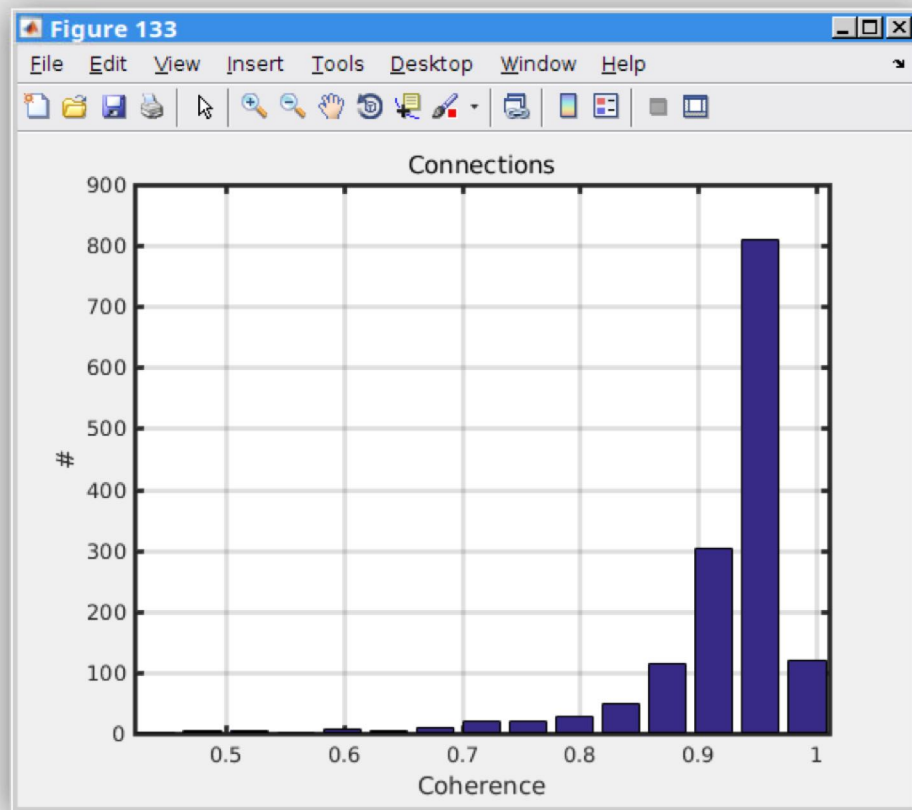
The screenshot displays the APS Processing software interface with the following sections:

- Images Combination:** STAR, 1 sensor (dropdown), Plot Graph (button), Images Nr. 64, Conn. Nr. 64, Missing APS: 64, Update Mode (radio), APS pre-removal (radio).
- Sparse Points Selection:** Parameter: Amp. Stab. Index 1-Sigm... (dropdown), Thresh. .85, DS 20, DL 0, PSC Nr: 502, Go (green button), Plot (button), Save (button), Load (button).
- Graph Creation:** Delaunay (dropdown), Min Nr 10, Min R 30, Max R Inf, Go (green button), Plot (button), Connections Nr: 1488, Save (button), Load (button).
- Processing Parameters:**

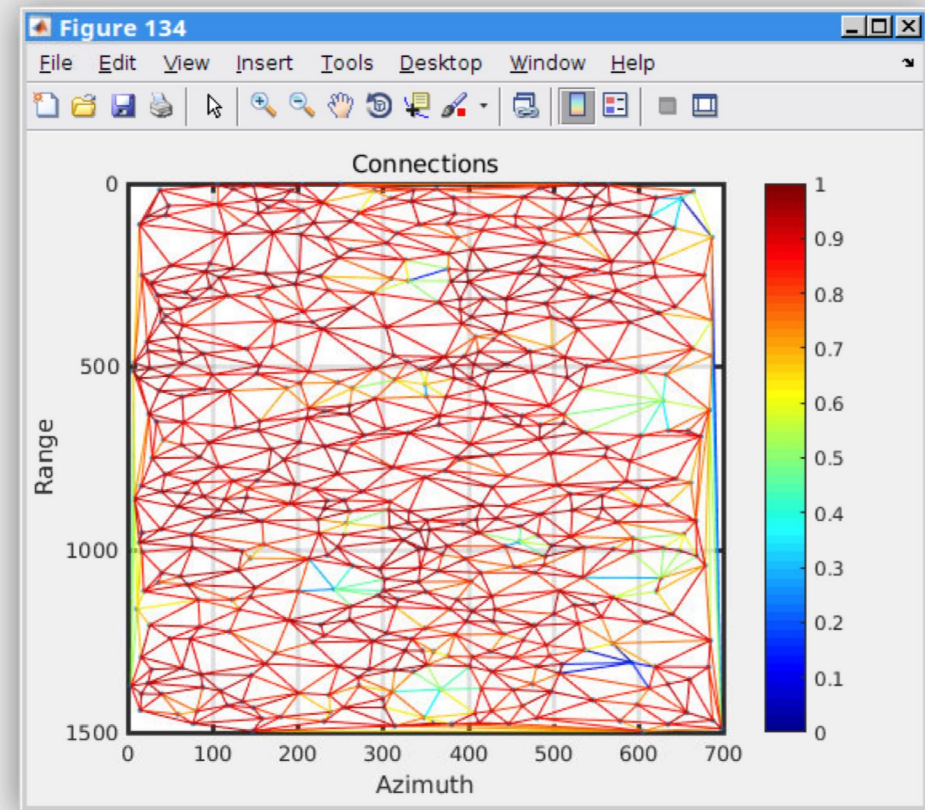
	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-5	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-20	20
Azimuth Pos.	<input type="radio"/>	<input type="radio"/>	<input checked="" 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 (radio), UW (radio), Smart 0, N min Gen 50, Scattering Centers 1, Polynomial Order 1, Recover (checkbox), Matr. Coher. Win 15 15, Weights: None (radio), Coher (radio), Amps (radio).
- Connections processing:** Go (green button), Save As (button), Clear Diff (button), Load (green button).
- Connections coherence:** Hist (red box), Plot Graph (red box), N Stats (button), Non-Linear Weighting: m 0.52, p 0.74, M 0.95, Plot (button).
- Reference Point:** Auto (dropdown), Go (red button), Plot (button), Nr 0, < (button), > (button).
- Estimated Parameters:** R 1, r0 1, ds 10, Flatten (radio), Optional Save (button), Optional Export TS (button).
- APS options:** Type Inverted Residuals (dropdown), Stratif. (checkbox), R 150, DSF 25.
- APS Estimate:** Go (button), Plot (button), Test (button), OK (button).

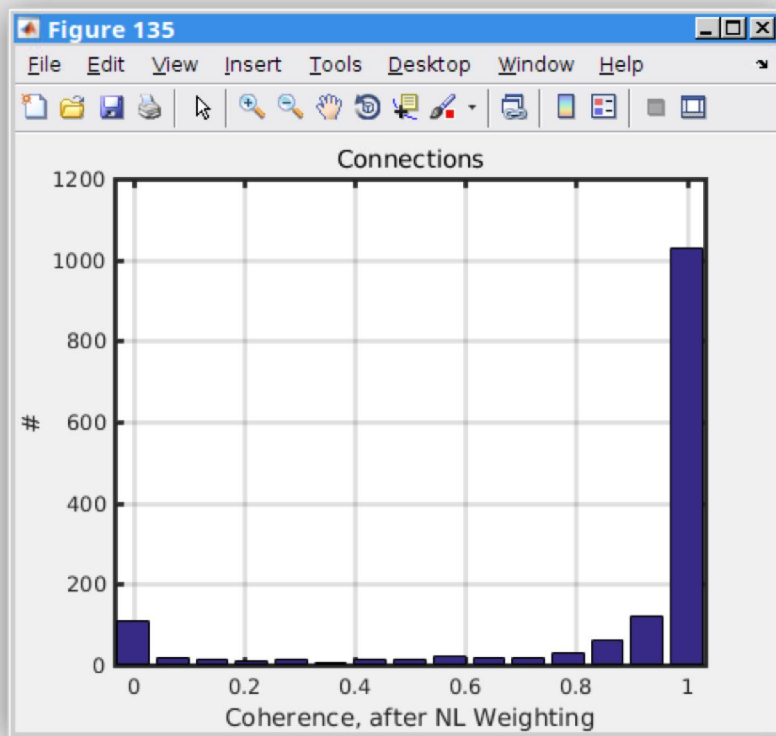
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The histogram of graph connection coherence



The plot of graph connection coherence. In this example, most points are connected via paths with relatively high coherence.



Step 2-7: non-linear weighting

Put down “0.8” as minimum (m) and keep “0.95” as maximum (M). Click “plot” to see the histogram after the non-linear weighting.

APS Processing - /data2/LA_small/

Images Combination: STAR, 1 sensor Images Nr. 64 Conn. Nr. 64 Missing APS: 64 ☐ Update Mode ☐ APS pre-removal

Sparse Points Selection
Parameter: Amp. Stab. Index 1-Sigm... Thresh. .85 DS 20 DL 0 PSC Nr: 502

Graph Creation
Delaunay Min Nr 10 Min R 30 Max R Inf Connections Nr: 1488

Processing Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-5	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-20	20
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 Gen 50

Scattering Centers 1 Polynomial Order 1 ☐ Recover

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

Connections processing

Connections coherence Non-Linear Weighting
m .8 p 0.88 M 0.95

Reference Point
Auto Nr 0 < >

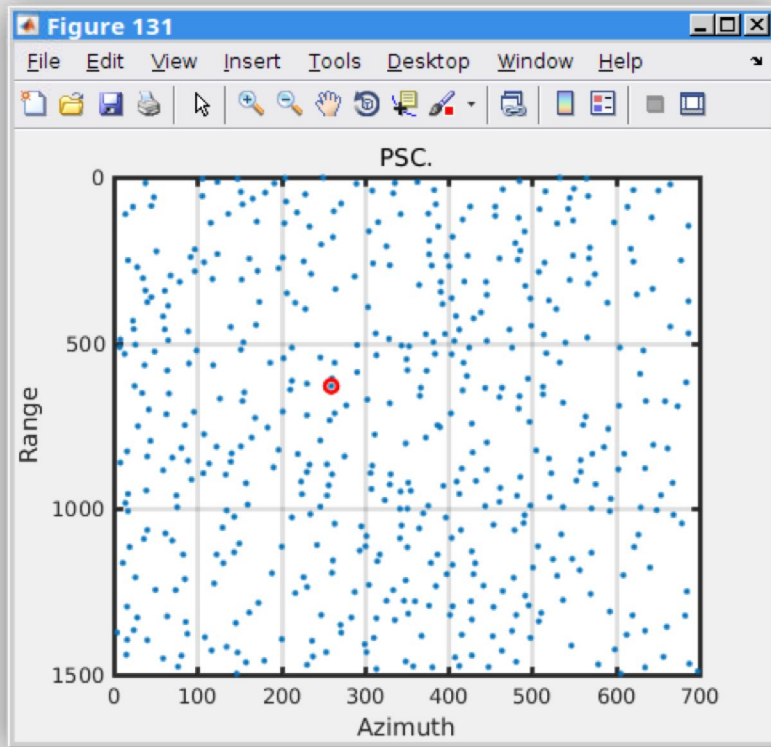
S: , L:

Estimated Parameters
 R 1 r0 1 ds 10 Flatten ☐ Optional Optional

APS options
Type Inverted Residuals ☐ Stratif. R 150 DSF 25

APS Estimate

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Step 2-8: automatic reference point

Select reference point. Click “go” to generate the automatic points, then click “plot” to show the point’s location. Click “<” and “>” to switch between reference points. Every time you switch reference point, click “plot” to see the new one.

APS Processing - /data2/LA_small/

Images Combination: STAR, 1 sensor Images Nr. 64 Conn. Nr. 64 Missing APS: 64 ☐ Update Mode ☐ APS pre-removal

Sparse Points Selection
Parameter: Amp. Stab. Index 1-Sigm... Thresh. .85 DS 20 DL 0 PSC Nr: 502

Graph Creation
Delaunay Min Nr 10 Min R 30 Max R Inf Connections Nr: 1488

Processing Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-5	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-20	20
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 Gen 50

Scattering Centers 1 Polynomial Order 1 ☐ Recover

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

Connections processing

Connections coherence Non-Linear Weighting m .8 p 0.88 M 0.95

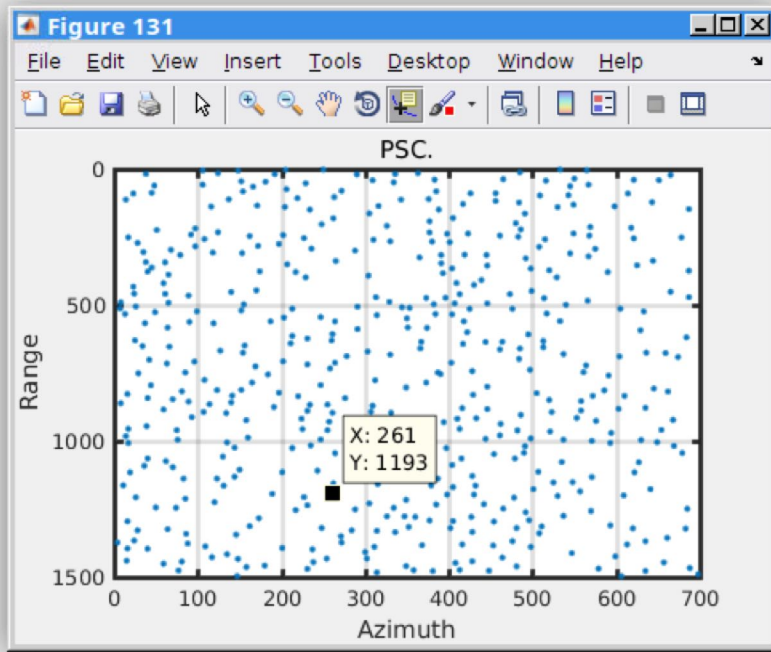
Reference Point Auto Nr 1
S: 630, L: 260

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

APS options Type Inverted Residuals ☐ Stratif. R 150 DSF 25

APS Estimate

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Step 2-9: manual reference point

Select reference point manually. Choose “manual” from the drop down menu. A figure will pop up. Use the “data cursor” tool to select reference point. After you select a point, click “save” in “reference point” frame to record your point.

APS Processing - /data2/LA_small/

Images Combination: STAR, 1 sensor Images Nr. 64 Conn. Nr. 64 Missing APS: 64 ☐ Update Mode ☐ APS pre-removal

Sparse Points Selection
Parameter: Amp. Stab. Index 1-Sigm... Thresh. .85 DS 20 DL 0 PSC Nr: 502

Graph Creation
Delaunay Min Nr 10 Min R 30 Max R Inf Connections Nr: 1488

Processing Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-5	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-20	20
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 Gen 50

Scattering Centers 1 Polynomial Order 1 ☐ Recover

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

Connections processing

Connections coherence Non-Linear Weighting m .8 p 0.88 M 0.95

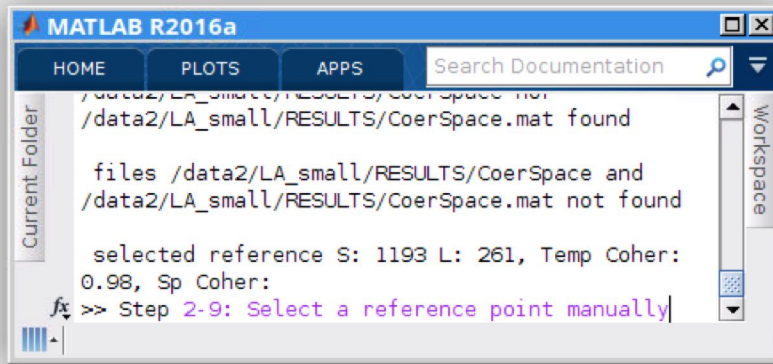
Reference Point Manual Nr S: 1193, L: 261

Estimated Parameters R 1 r0 1 ds 10 Flatten ☐ Optional Optional

APS options Type Inverted Residuals ☐ Stratif. R 150 DSF 25

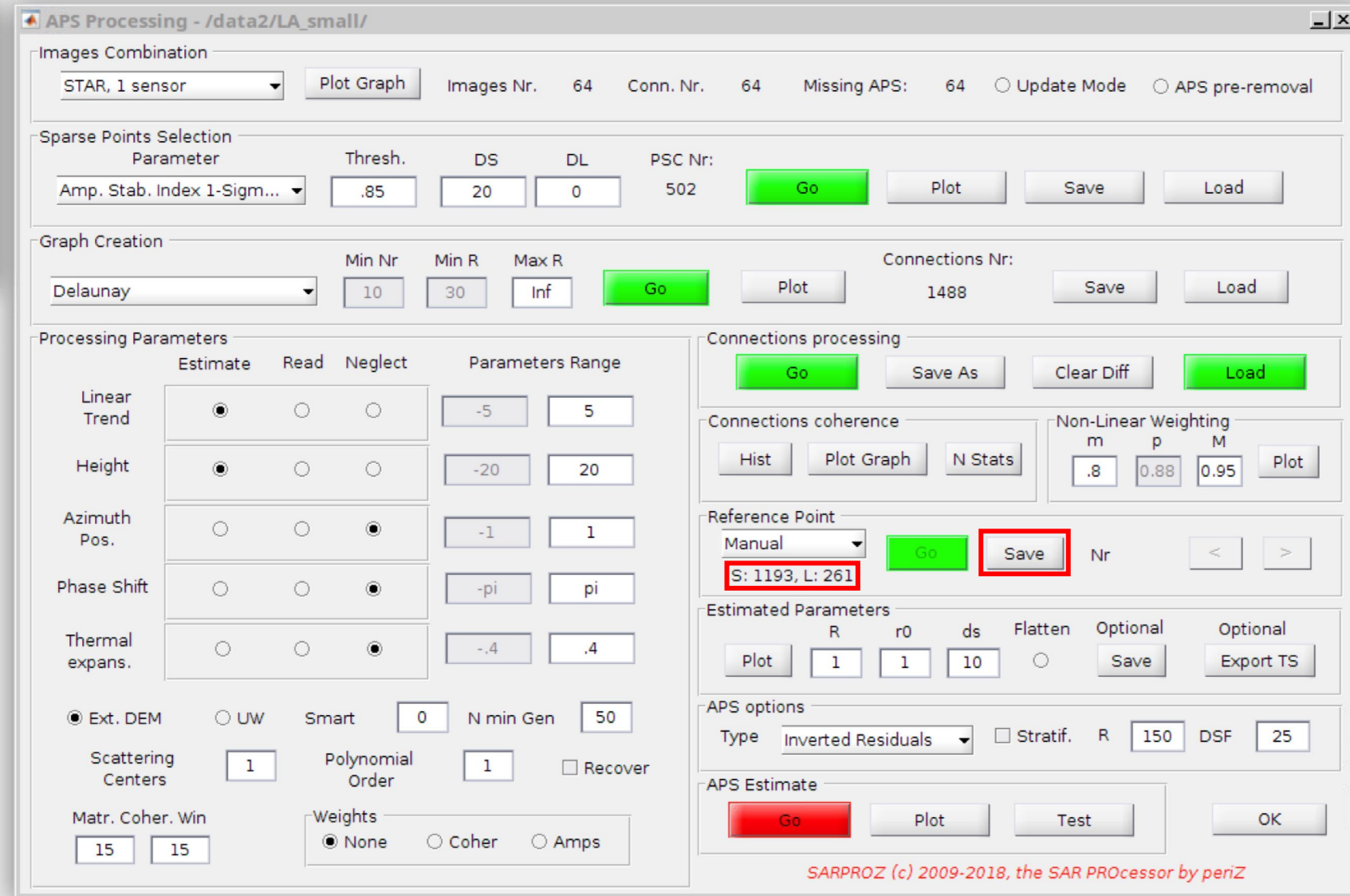
APS Estimate

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Step 2-9 (cont'd)

When you are choosing your reference points with the data cursor, you can see the coherence value of the point you selected in the command window. It is desired to have the reference point with high temporal coherence. For this exercise, we manually select point with sample: 1193 and line: 261 as the reference point.



Why is selecting reference point important?

- Remember that InSAR measures the relative movement to the reference point. Hence, it is important to select a point that is most likely to be stable as the reference point.
- A stable reference point should have the following property:
 - the peak of residual height histogram should be at value 0. This indicates your reference point is on the ground (points not on the ground are more likely to be unstable);
 - the peak of estimated velocity histogram should also be at value 0. This indicates the reference point is relatively stable (assuming the majority points in your AOI is stable).

Step 2-10: plot parameters

Click “plot” in the “estimated parameters” frame to check the integrated estimated parameters.

APS Processing - /data2/LA_small/

Images Combination
STAR, 1 sensor Plot Graph Images Nr. 64 Conn. Nr. 64 Missing APS: 64 ☐ Update Mode ☐ APS pre-removal

Sparse Points Selection
Parameter Thresh. DS DL PSC Nr:
Amp. Stab. Index 1-Sigm... .85 20 0 502 Go Plot Save Load

Graph Creation
Delaunay Min Nr 10 Min R 30 Max R Inf Go Plot Connections Nr: 1488 Save Load

Processing Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-5	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-20	20
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 Gen 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
.8 0.88 0.95 Plot

Reference Point
Manual Go Save Nr < >
S: 1193, L: 261

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

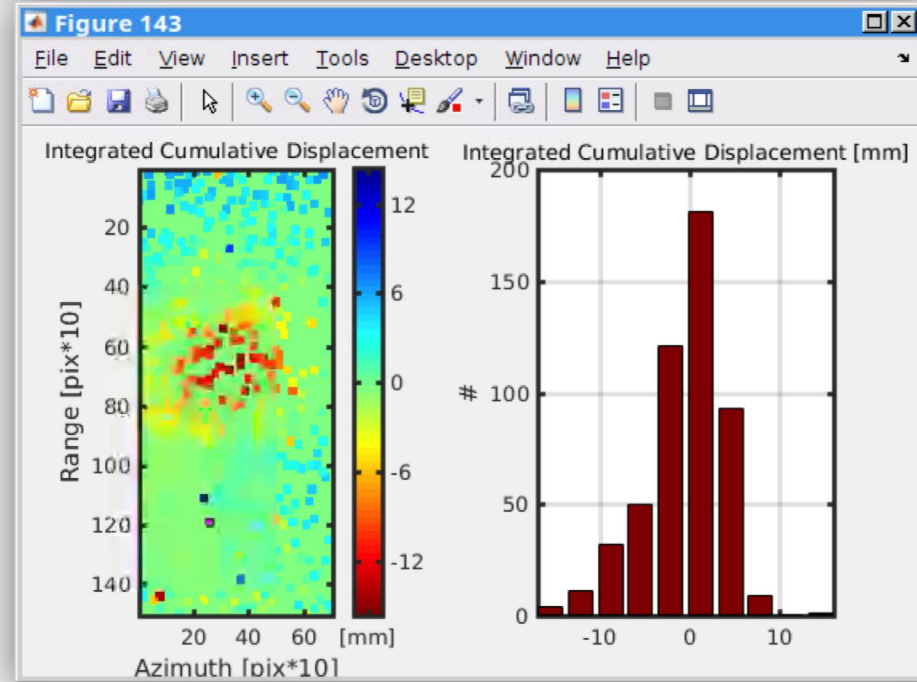
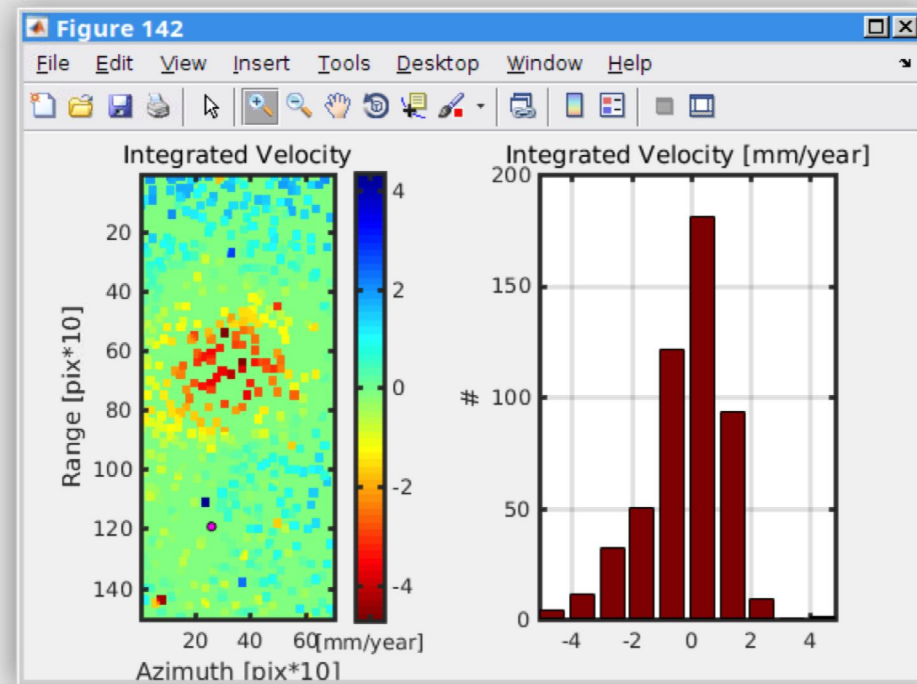
APS options
Type Inverted Residuals ☐ Stratif. R 150 DSF 25

APS Estimate
Go Plot Test OK

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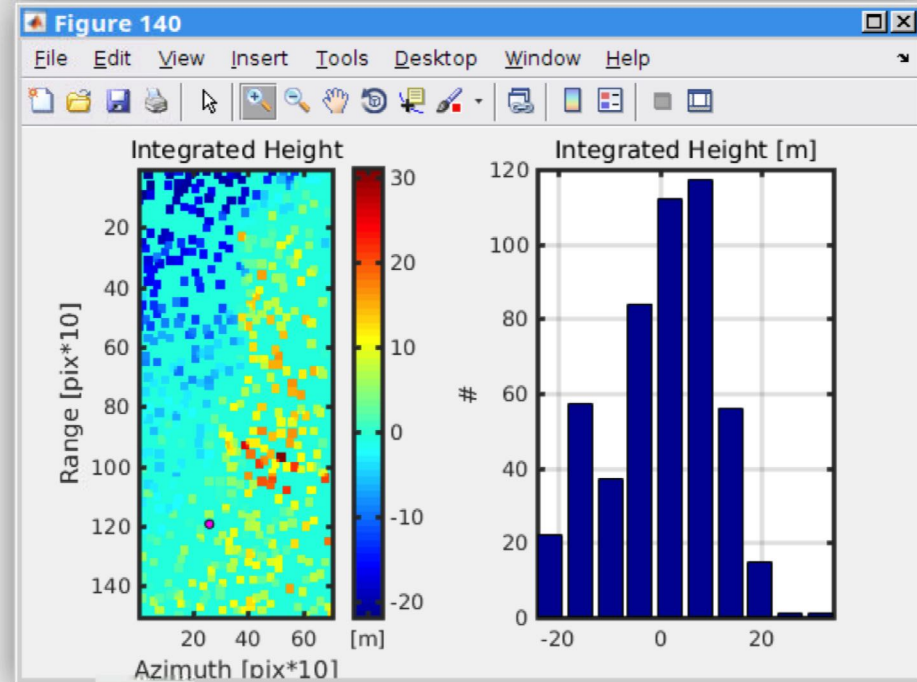
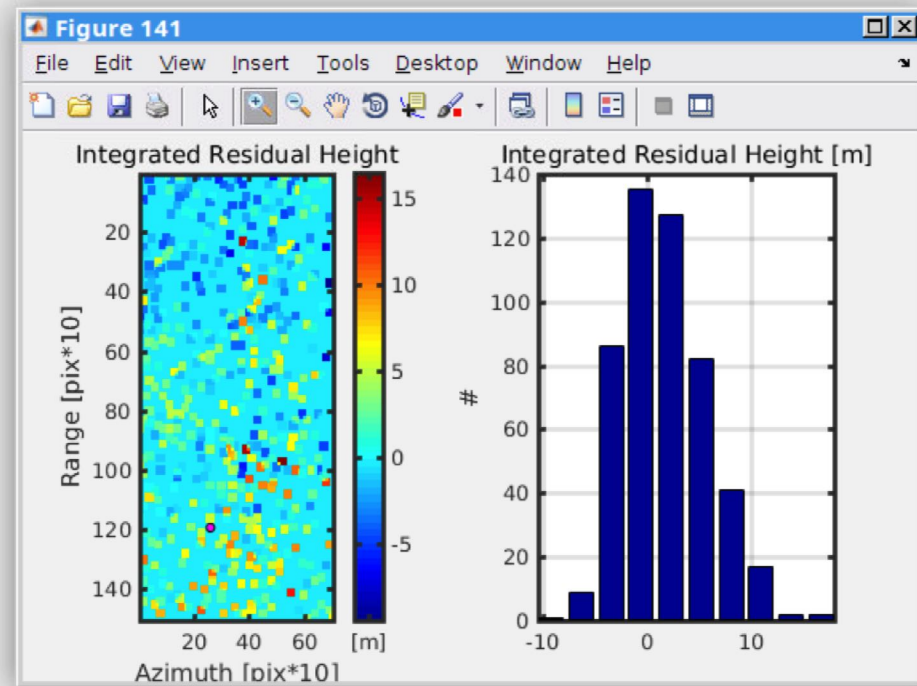
Step 2-10 (cont'd)

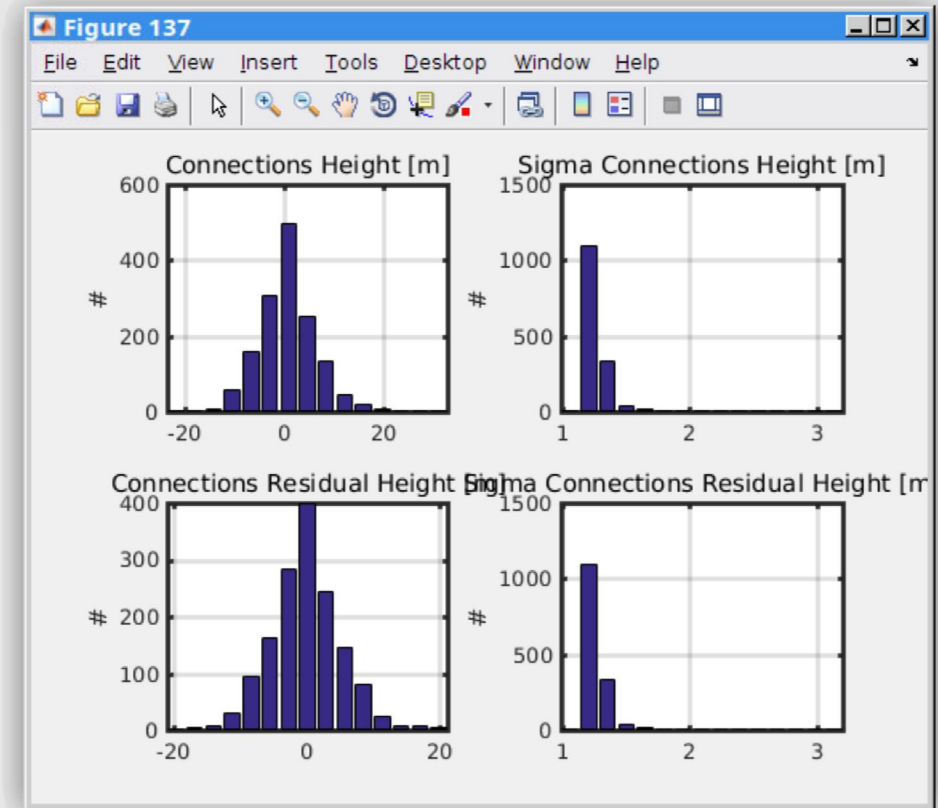
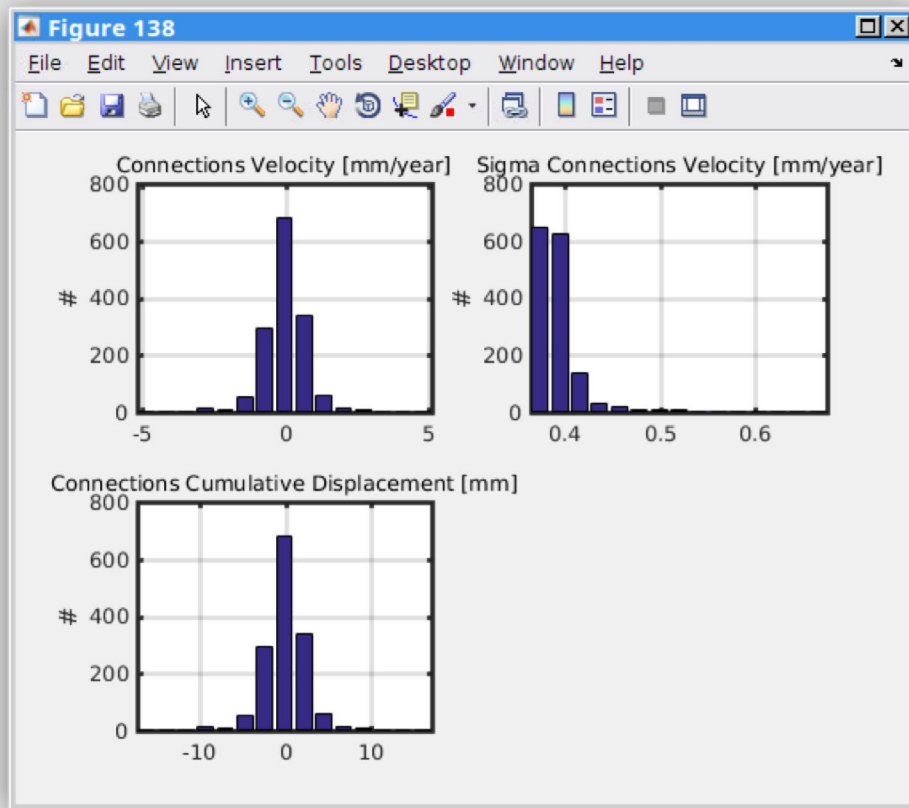
Integrated velocity and integrated cumulative displacement.
Cumulative displacement = velocity \times time. Note the peak of integrated velocity histogram (and integrated cumulative displacement histogram) is more or less at zero. This means that the majority of points have zero relative velocity when comparing with the reference point.



Step 2-10 (cont'd)

Integrated residual height and integrated height. Integrated residual height is the integrated height minus the external DEM. Note the peak of integrated residual height histogram is more or less at zero. This means that the majority of points have zero relative height comparing with the reference point. This is an indication that the reference point is on the ground (since the majority of points should be on the ground).





The histogram of connections velocity, connections heights and connections residual height. Note that this is the histogram of connections of the graph.

What is the difference between connections (histogram) and integrated parameters (histogram)?

- Connections velocity/residual height is the estimated relative velocity/residual height between two points that are connected with an edge of the graph.
 - The histogram is the representation for the distribution of the connections velocity/residual height.
- Integrated velocity/residual height is the velocity/residual height with respect to the reference point after integrating the connections velocity/residual height using the given graph.
 - The histogram represents the distribution of the integrated velocity/residual height for each point with respect to the reference point.

Step 2-11: estimate APS

When you believe your estimated parameters are reasonable, you can now proceed to the APS estimation. Keep the default option of “inverted residuals” in “APS options” frame. At last, click “go” in “APS estimate” frame.

The screenshot displays the 'APS Processing' software window with the following sections:

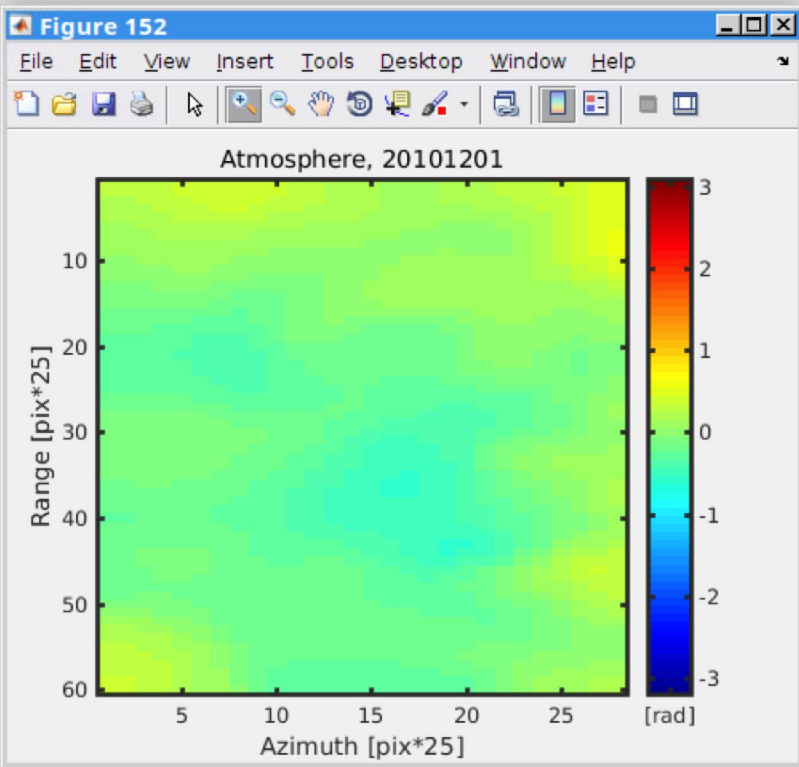
- Images Combination:** STAR, 1 sensor (dropdown), Plot Graph (button). Images Nr. 64, Conn. Nr. 64, Missing APS: 64. Update Mode (radio), APS pre-removal (radio).
- Sparse Points Selection:** Parameter: Amp. Stab. Index 1-Sigm... (dropdown), Thresh. .85, DS 20, DL 0, PSC Nr: 502. Go (green button), Plot (button), Save (button), Load (button).
- Graph Creation:** Delaunay (dropdown), Min Nr 10, Min R 30, Max R Inf, Go (green button), Plot (button), Connections Nr: 1488, Save (button), Load (button).
- Processing Parameters:**

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-5	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-20	20
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 (radio), UW (radio), Smart 0, N min Gen 50, Scattering Centers 1, Polynomial Order 1, Recover (checkbox), Matr. Coher. Win 15 15, Weights: None (radio), Coher (radio), Amps (radio).
- Connections processing:** Go (green button), Save As (button), Clear Diff (button), Load (green button).
- Connections coherence:** Hist (button), Plot Graph (button), N Stats (button). Non-Linear Weighting: m .8, p 0.88, M 0.95, Plot (button).
- Reference Point:** Manual (dropdown), Go (green button), Save (button), Nr, < (button), > (button). S: 1193, L: 261.
- Estimated Parameters:** Plot (button), R 1, r0 1, ds 10, Flatten (radio), Optional Save (button), Optional Export TS (button).
- APS options:** Type Inverted Residuals (dropdown, highlighted with a red box), Stratif. (checkbox), R 150, DSF 25.
- APS Estimate:** Go (green button, highlighted with a red box), Plot (button), Test (button), OK (button).

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Runtime: 4s - ETA: 0.66s
Weights Inversion
80%



Step 2-12: plot APS

Click “plot” in “APS estimation” frame.
You can browse the estimated APS contribution in phase one by one.

APS Processing - /data2/LA_small/

Images Combination: STAR, 1 sensor Images Nr. 64 Conn. Nr. 64 Missing APS: 0 ☐ Update Mode ☐ APS pre-removal

Sparse Points Selection
Parameter: Amp. Stab. Index 1-Sigm... Thresh. .85 DS 20 DL 0 PSC Nr: 502

Graph Creation
Delaunay Min Nr 10 Min R 30 Max R Inf Connections Nr: 1488

Processing Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-5	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-20	20
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 Gen 50

Scattering Centers 1 Polynomial Order 1 ☐ Recover

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

Connections processing

Connections coherence Non-Linear Weighting m .8 p 0.88 M 0.95

Reference Point Manual Nr S: 1193, L: 261 < >

Estimated Parameters R 1 r0 1 ds 10 Flatten ☐ Optional Optional

APS options Type Inverted Residuals ☐ Stratif. R 150 DSF 25

APS Estimate

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Step 2-13: test

At last, you can “test” the coherence after removing the estimated APS. If the coherence is high, it means the APS estimation is good.

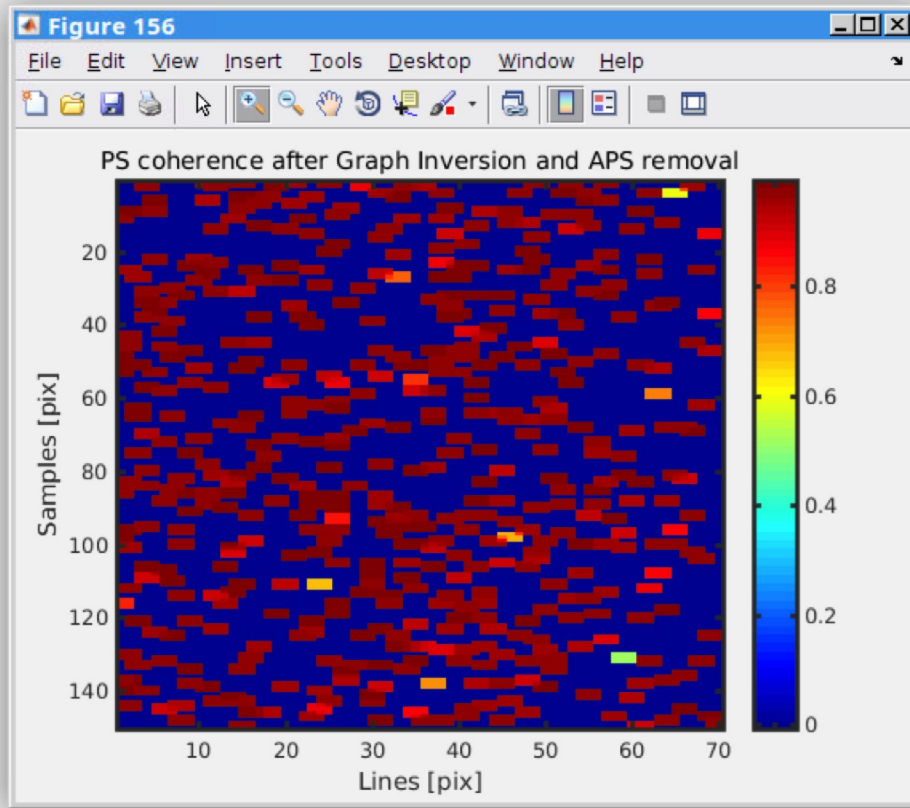
The screenshot displays the 'APS Processing' software window with the following sections:

- Images Combination:** STAR, 1 sensor (dropdown), Plot Graph (button), Images Nr. 64, Conn. Nr. 64, Missing APS: 0, Update Mode (radio), APS pre-removal (radio).
- Sparse Points Selection:** Parameter: Amp. Stab. Index 1-Sigm... (dropdown), Thresh. .85, DS 20, DL 0, PSC Nr: 502, Go (button), Plot (button), Save (button), Load (button).
- Graph Creation:** Delaunay (dropdown), Min Nr 10, Min R 30, Max R Inf, Go (button), Plot (button), Connections Nr: 1488, Save (button), Load (button).
- Processing Parameters:**

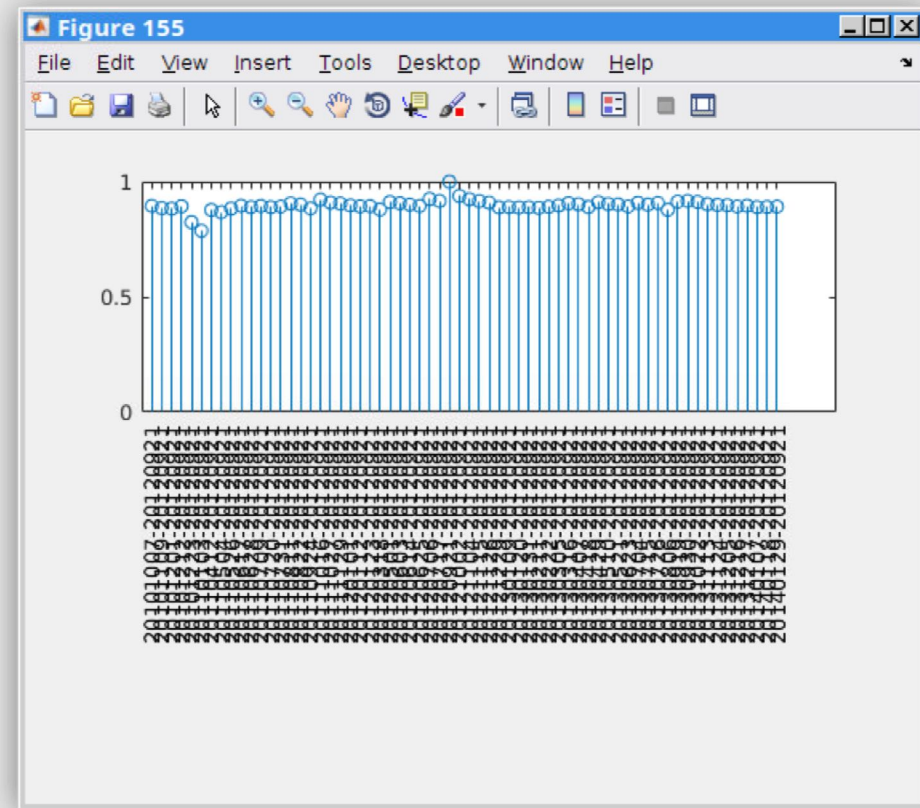
	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-5	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-20	20
Azimuth Pos.	<input type="radio"/>	<input type="radio"/>	<input checked="" 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 (radio), UW (radio), Smart 0, N min Gen 50, Scattering Centers 1, Polynomial Order 1, Recover (checkbox), Matr. Coher. Win 15 15, Weights: None (radio), Coher (radio), Amps (radio).
- Connections processing:** Go (button), Save As (button), Clear Diff (button), Load (button).
- Connections coherence:** Hist (button), Plot Graph (button), N Stats (button), Non-Linear Weighting: m .8, p 0.88, M 0.95, Plot (button).
- Reference Point:** Manual (dropdown), Go (button), Save (button), Nr, < (button), > (button), S: 1193, L: 261.
- Estimated Parameters:** Plot (button), R 1, r0 1, ds 10, Flatten (radio), Optional Save (button), Optional Export TS (button).
- APS options:** Type Inverted Residuals (dropdown), Stratif. (checkbox), R 150, DSF 25.
- APS Estimate:** Go (button), Plot (button), **Test (button)**, OK (button).

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Temporal coherence of points after removing the estimated APS



Coherence between each slave date and the master date after removing the estimated APS

Step 2-14:

At this moment we are done with APS estimation part. You can now click “ok” to close this module.

The screenshot shows the 'APS Processing' window with the following sections:

- Images Combination:** STAR, 1 sensor (dropdown), Plot Graph (button), Images Nr. 64, Conn. Nr. 64, Missing APS: 0, Update Mode (radio), APS pre-removal (radio).
- Sparse Points Selection:** Parameter: Amp. Stab. Index 1-Sigm... (dropdown), Thresh. .85, DS 20, DL 0, PSC Nr: 502, Go (green button), Plot (button), Save (button), Load (button).
- Graph Creation:** Delaunay (dropdown), Min Nr 10, Min R 30, Max R Inf, Go (green button), Plot (button), Connections Nr: 1488, Save (button), Load (button).
- Processing Parameters:**

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-5	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-20	20
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 (radio), UW (radio), Smart 0, N min Gen 50, Scattering Centers 1, Polynomial Order 1, Recover (checkbox), Matr. Coher. Win 15 15, Weights: None (radio), Coher (radio), Amps (radio).
- Connections processing:** Go (green button), Save As (button), Clear Diff (button), Load (green button).
- Connections coherence:** Hist (button), Plot Graph (button), N Stats (button), Non-Linear Weighting: m .8, p 0.88, M 0.95, Plot (button).
- Reference Point:** Manual (dropdown), Go (green button), Save (button), Nr, < (button), > (button), S: 1193, L: 261.
- Estimated Parameters:** Plot (button), R 1, r0 1, ds 10, Flatten (radio), Optional Save (button), Optional Export TS (button).
- APS options:** Type Inverted Residuals (dropdown), Stratif. (checkbox), R 150, DSF 25.
- APS Estimate:** Go (green button), Plot (button), Test (button), **OK (button, highlighted with a red border)**.

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Part 3:

Multi-temporal Analysis

Step 3-1: open MISP module

Click “sparse points processing” from “site processing” panel.

Multi-Image Sparse Points Processing - /data2/LA_small/

Images Combination

STAR, 1 sensor

Images Nr.64Conn. Nr.64

Plot Graph

☐ Update Mode

Sparse Points Selection

Parameter

Thresh.

Points Nr:

☐ All

Go

Plot

Save

Load

Not Processed:

Reference

Load

None

Phase

Save as

Read

Load

APS

INV. RES.

Save as

Read

Load

Sparse Points Processing

Go

N Stats

Plot Hist

Plot Param

R

1

r0

1

ds

10

Plot Res

Plot Coher

☒ Update

☐ Replace

Save Param

Save Coher

Final Fine APS

RFil

150

DSF

25

Non-Linear Weighting

m

0

p

0.5

M

1

☐ Stratific.

Save APS

View APS

Project Management

Save PRJ

Load PRJ

Export TS

Coher. Thres.

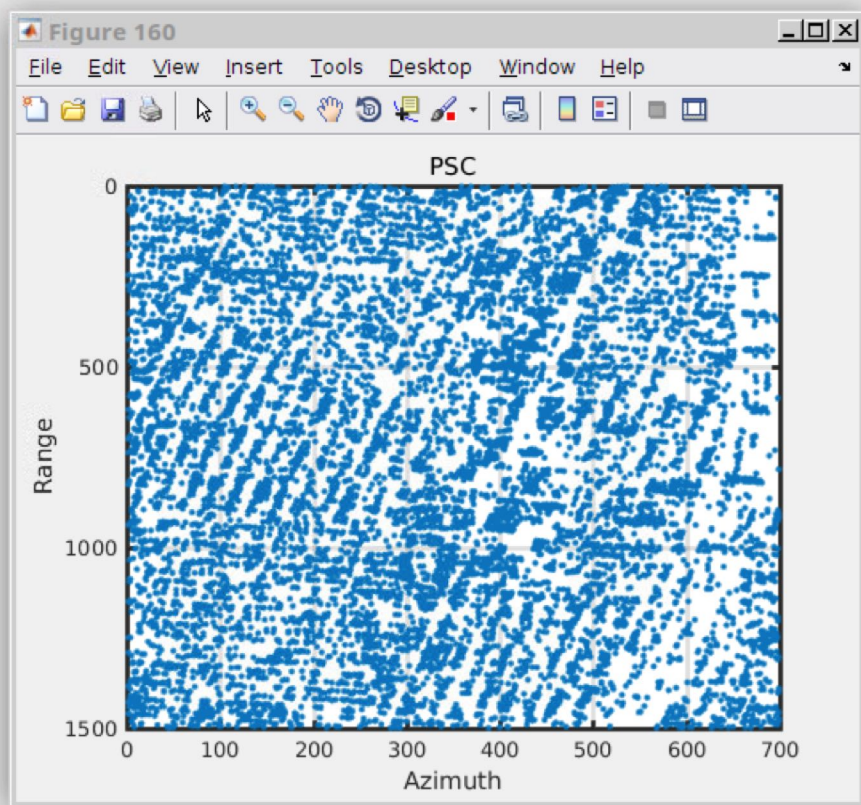
0

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OK

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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4
<input checked="" type="radio"/> Ext. DEM	<input type="radio"/> UW	Smart	<div>0</div>	N min Gen	<div>50</div>
Scattering Centers	<div>1</div>	Polynomial Order	<div>1</div>	<input type="checkbox"/> Recover	
Matr. Coher. Win	<div>15</div>	<div>15</div>	Weights <div><input checked="" type="radio"/> None<input type="radio"/> Coher<input type="radio"/> Amps</div>		



Step 3-2: select points

Choose “amplitude stability index” and put down “0.69” as the selection threshold. Click “go” to count the points. These are the points for which you will calculate the time series. Click “plot” for seeing the locations of points.

Multi-Image Sparse Points Processing - /data2/LA_small/

Images Combination: STAR, 1 sensor | Images Nr. 64 | Conn. Nr. 64 | Plot Graph | Update Mode

Sparse Points Selection

Parameter: Amp. Stab. Index 1-Sig... | Thresh.: .69 | Points Nr.: 10923 | Not Processed: 10923 | All | **Go** | **Plot** | Save | Load

Reference

Load | None

Phase

Save as | APS: INV. RES. | Save as | Read | Load | Read | Load

Sparse Points Processing

Go | N Stats | Plot Hist | Plot Param | R: 1 | r0: 1 | ds: 10 | Plot Res | Plot Coher | Update | Replace | Save Param | Save Coher

Final Fine APS

Rfil: 150 | DSF: 25 | Non-Linear Weighting: m: 0 | p: 0.5 | M: 1 | Stratific. | Save APS | View APS

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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4

Ext. DEM: ☒ | UW: ☐ | Smart: 0 | N min Gen: 50

Scattering Centers: 1 | Polynomial Order: 1 | Recover: ☐

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

Project Management

Save PRJ | Load PRJ | Export TS | Coher. Thres.: 0

SARPROZ (c) 2009-2018, the SAR PROcessor by perizZ | OK

Step 3-3: estimate parameters

Select “estimate” for height and linear trend, and “neglect” for all other parameters. Put down $[-10, 5]$ for linear trend estimation. Put down $[-10, 20]$ for height estimation. Make sure that “ext. DEM” option is checked. Keep all other options as in their default settings. Click “go” in “sparse point processing” to estimate the parameters for your selected points.

Multi-Image Sparse Points Processing - /data2/LA_small/

Images Combination: STAR, 1 sensor | Images Nr. 64 | Conn. Nr. 64 | Plot Graph | Update Mode

Sparse Points Selection: Parameter: Amp. Stab. Index 1-Sig... | Thresh. .69 | Points Nr: 10923 | Not Processed: 10923 | All | Go | Plot | Save | Load

Reference: Load | RefPoint, Sample: 1193 Line: 261

Phase: Save as | APS: INV. RES. | Save as | Read | Load | Read | Load

Sparse Points Processing: Go | N Stats | Plot Hist | Plot Param | R 1 | r0 1 | ds 10 | Plot Res | Plot Coher | Update | Replace | Save Param | Save Coher

Final Fine APS: RFil 150 | DSF 25 | Non-Linear Weighting: m 0 | p 0.5 | M 1 | Stratific. | Save APS | View APS

Project Management: Save PRJ | Load PRJ | Export TS | Coher. Thres. 0

Processing Parameters:

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	20
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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4
Ext. DEM	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	Smart 0	N min Gen 50
Scattering Centers	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	1	Polynomial Order 1 Recover
Matr. Coher. Win	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	15 15	Weights: None Coher Amps

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OK

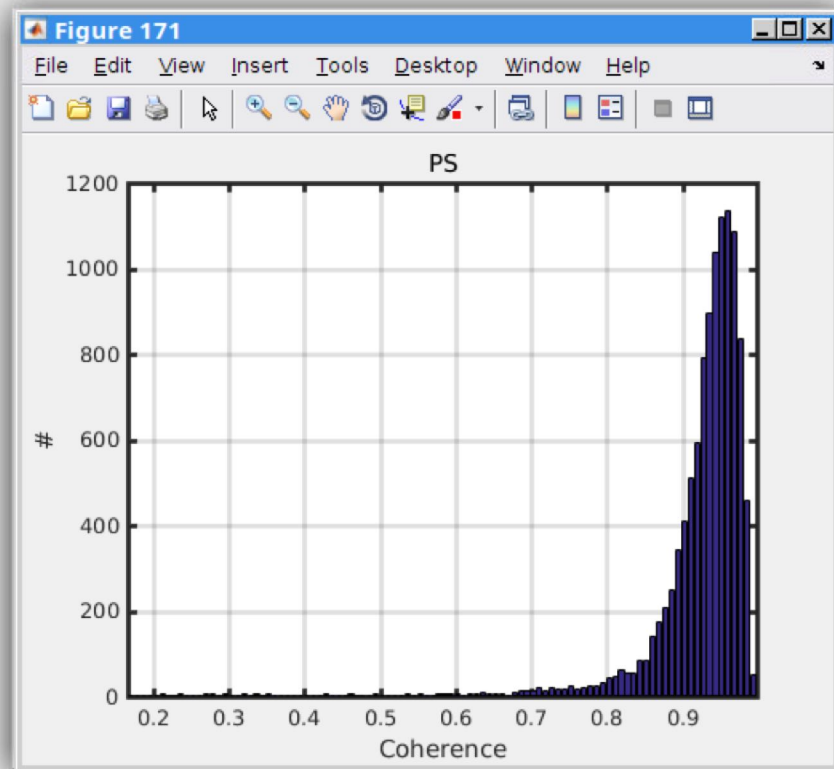
Runtime: 7s - ETA: 96.04s

Phase series processing

7%

How to select the range for estimation here?

- In step 2-10, you see the integrated velocity and integrated residual height with their histograms. From the color bar and histogram you should see the range (distribution) of integrated velocity and integrated residual height. Put down the range for each parameter (velocity and residual height) that is just slightly bigger than you have observed in step 2-10.



Step 3-4: check coherence histogram

Click “plot hist.” in “sparse points processing” frame to check the temporal coherence histogram of points after parameter estimation and APS removal.

Multi-Image Sparse Points Processing - /data2/LA_small/

Images Combination: STAR, 1 sensor | Images Nr. 64 | Conn. Nr. 64 | Plot Graph | Update Mode

Sparse Points Selection: Parameter: Amp. Stab. Index 1-Sig... | Thresh. .69 | Points Nr: 10923 | Not Processed: 10923 | All | Go | Plot | Save | Load

Reference: Load | RefPoint, Sample: 1193 Line: 261

Phase: Save as | APS: INV. RES. | Save as | Read | Load | Read | Load

Sparse Points Processing: Go | N Stats | **Plot Hist** | Plot Param | R 1 | r0 1 | ds 10 | Plot Res | Plot Coher | Update | Replace | Save Param | Save Coher

Final Fine APS: Rfil 150 | DSF 25 | Non-Linear Weighting: m 0 | p 0.5 | M 1 | Stratific. | Save APS | View APS

Processing Parameters:

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	20
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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4

Ext. DEM ☒ | UW ☐ | Smart 0 | N min Gen 50

Scattering Centers 1 | Polynomial Order 1 | Recover ☐

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

Project Management: Save PRJ | Load PRJ | Export TS | Coher. Thres. 0

SARPROZ (c) 2009-2018, the SAR PROcessor by perizZ | OK

Step 3-5: plot parameters

Click “plot param.” to plot your estimated parameters.

Multi-Image Sparse Points Processing - /data2/LA_small/

Images Combination

STAR, 1 sensor

Images Nr.64

Conn. Nr.64

Plot Graph

☐ Update Mode

Sparse Points Selection

Parameter

Amp. Stab. Index 1-Sig...

Thresh. .69

Points Nr: 10923

Not Processed: 10923

☒ All

Go

Plot

Save

Load

Reference

Load

RefPoint, Sample: 1193 Line: 261

Phase

Save as

Read

Load

APS

INV. RES.

Save as

Read

Load

Sparse Points Processing

Go

N Stats

Plot Hist

Plot Param

R1

r01

ds10

Plot Res

Plot Coher

☒ Update

☐ Replace

Save Param

Save Coher

Final Fine APS

Rfil

150

DSF

25

Non-Linear Weighting

m0

p0.5

M1

☐ Stratific.

Save APS

View APS

Project Management

Save PRJ

Load PRJ

Export TS

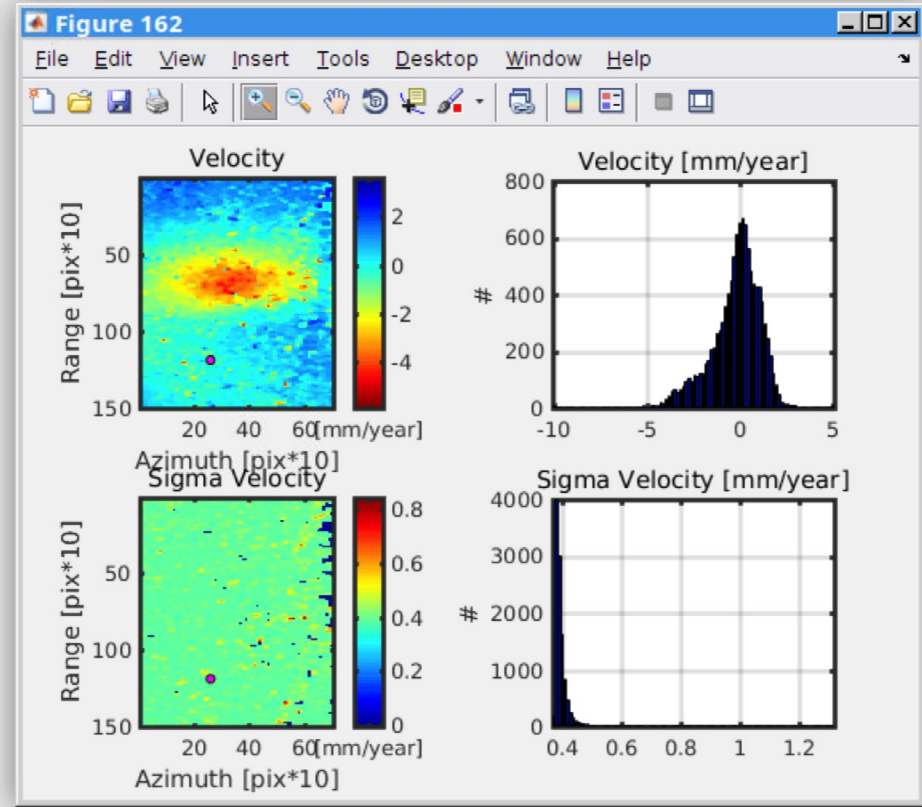
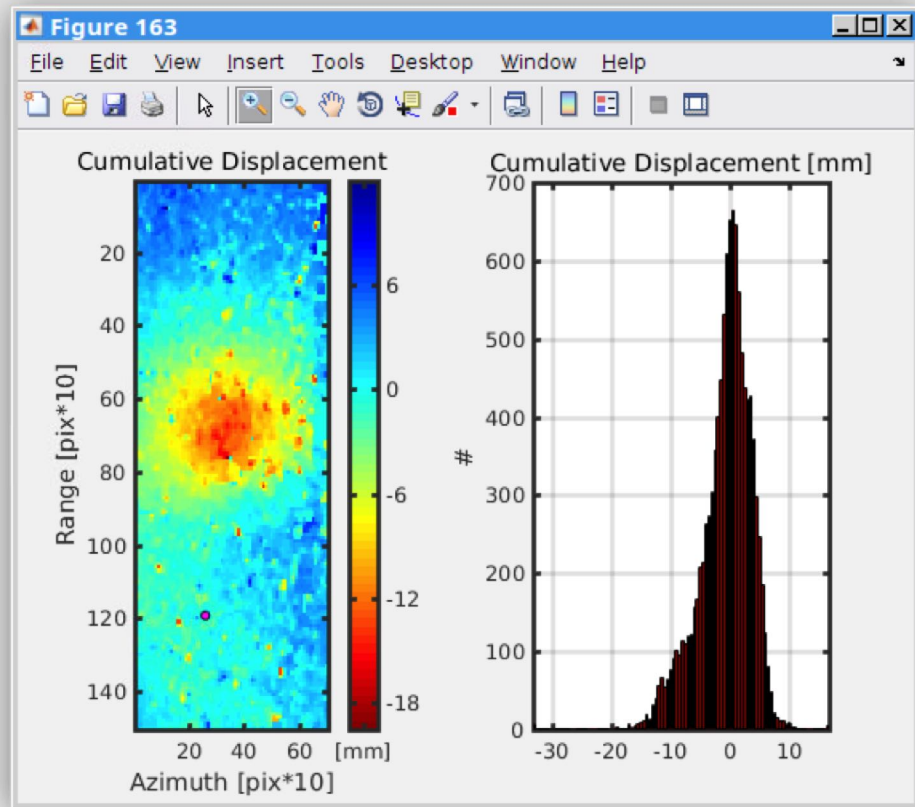
Coher. Thres.0

Processing Parameters

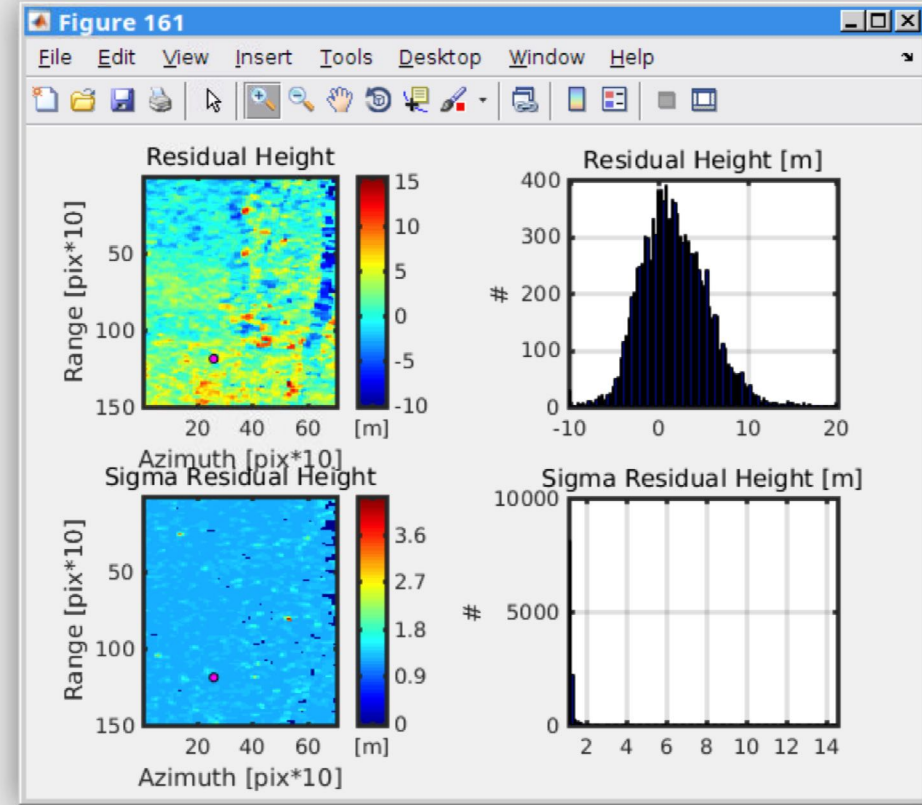
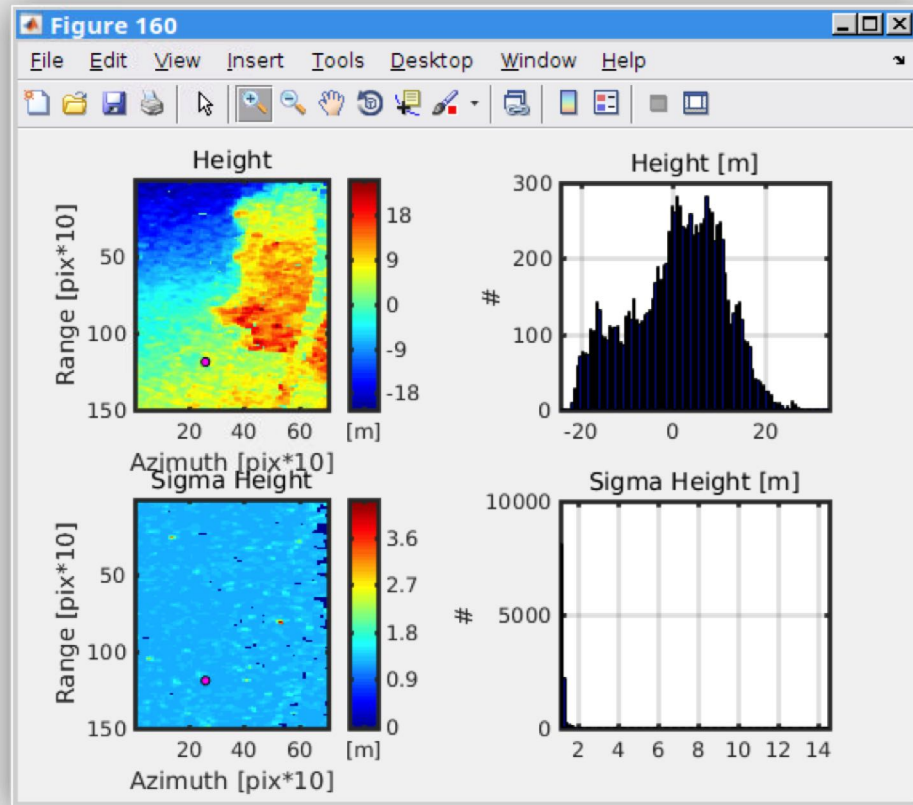
	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	20
Azimuth Pos.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-1	1
Phase Shift	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4
<input checked="" type="radio"/> Ext. DEM	<input type="radio"/> UW	Smart	0	N min Gen	50
Scattering Centers	1	Polynomial Order	1	<input type="checkbox"/> Recover	
Matr. Coher. Win	15	Weights	<input checked="" type="radio"/> None <input type="radio"/> Coher <input type="radio"/> Amps		

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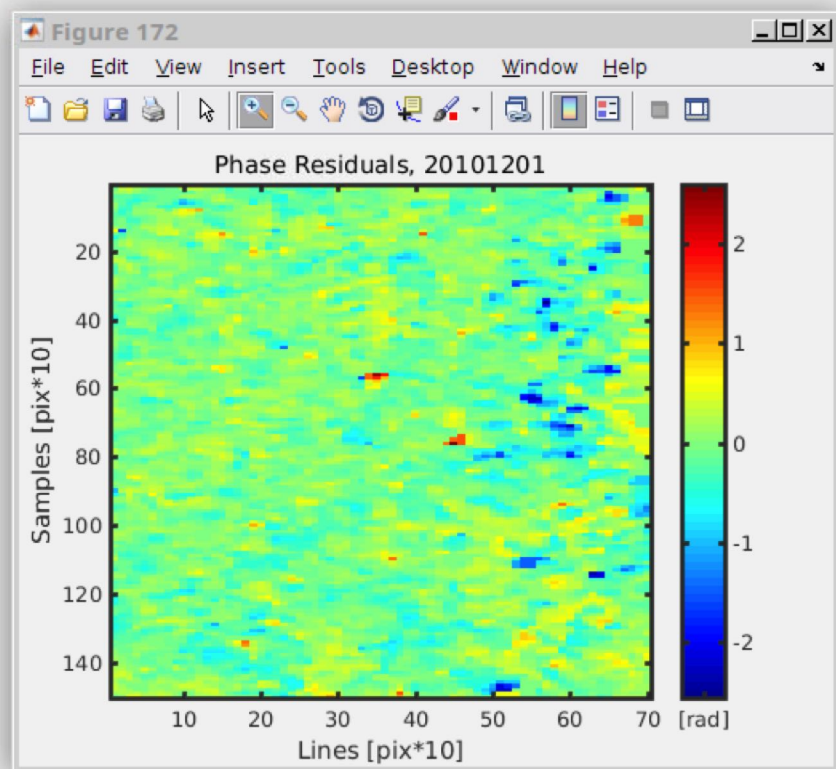
OK



Estimated velocity and cumulative displacement for the selected points. Note that again the peak of histogram is at zero, meaning that the most points have a zero relative velocity with the reference point, indicating that the reference point we selected is most likely to be stable.



Estimated height and residual height for the selected points. Note that again the peak of residual height histogram is at zero, meaning that the most points have a zero relative *residual height* with the reference point, indicating that the reference point is located on the ground.



Multi-Image Sparse Points Processing - /data2/LA_small/

Images Combination: STAR, 1 sensor | Images Nr. 64 | Conn. Nr. 64 | Plot Graph | Update Mode

Sparse Points Selection: Parameter: Amp. Stab. Index 1-Sig... | Thresh. .69 | Points Nr: 10923 | Not Processed: 10923 | All | Go | Plot | Save | Load

Reference: Load | RefPoint, Sample: 1193 Line: 261

Phase: Save as | APS: INV. RES. | Save as | Read | Load | Read | Load

Sparse Points Processing: Go | N Stats | Plot Hist | Plot Param | R 1 | r0 1 | ds 10 | Plot Res | Plot Coher | Update | Replace | Save Param | Save Coher

Final Fine APS: Rfil 150 | DSF 25 | Non-Linear Weighting: m 0 | p 0.5 | M 1 | Stratific. | Save APS | View APS

Processing Parameters:

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	20
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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4

Ext. DEM ☒ | UW ☐ | Smart 0 | N min Gen 50

Scattering Centers 1 | Polynomial Order 1 | Recover ☐

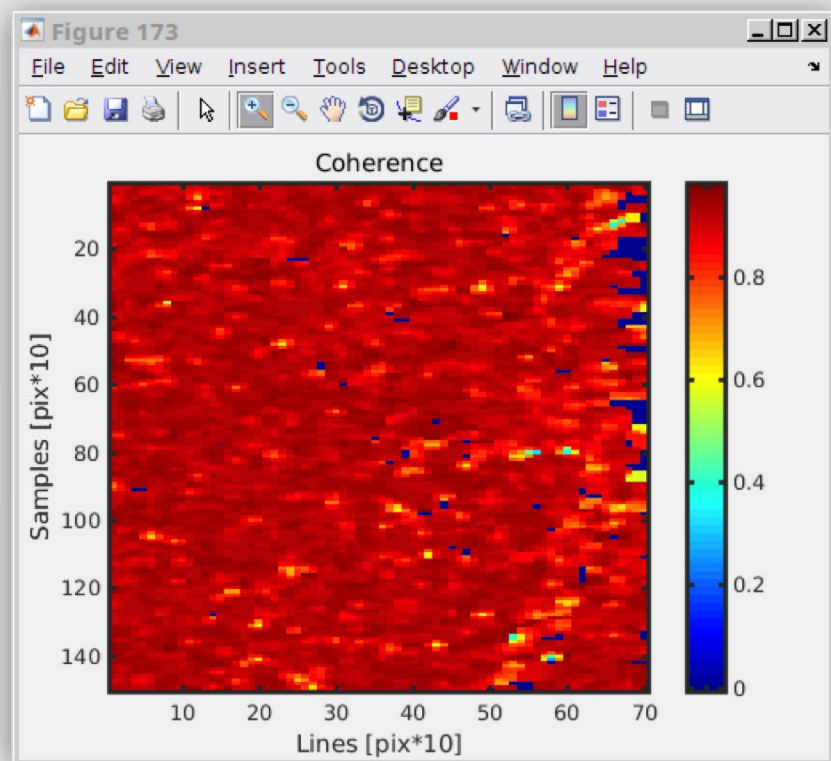
Matr. Coher. Win 15 15 | Weights: None ☒ | Coher ☐ | Amps ☐

Project Management: Save PRJ | Load PRJ | Export TS | Coher. Thres. 0

SARPROZ (c) 2009-2018, the SAR PROcessor by perizZ | OK

Step 3-6: residual phase

Click “plot res.” to check the residual phase one by one. Residual phase is what is left by removing phase from APS and the estimated parameters. If the parameters and APS are all well estimated, the residual phase should be small.



Multi-Image Sparse Points Processing - /data2/LA_small/

Images Combination: STAR, 1 sensor | Images Nr. 64 | Conn. Nr. 64 | Plot Graph | Update Mode

Sparse Points Selection: Parameter: Amp. Stab. Index 1-Sig... | Thresh. .69 | Points Nr: 10923 | Not Processed: 10923 | All | Go | Plot | Save | Load

Reference: Load | RefPoint, Sample: 1193 Line: 261

Phase: Save as | APS: INV. RES. | Save as | Read | Load | Read | Load

Sparse Points Processing: Go | N Stats | Plot Hist | Plot Param | R 1 | r0 1 | ds 10 | Plot Res | Plot Coher | Update | Replace | Save Param | Save Coher

Final Fine APS: RFil 150 | DSF 25 | Non-Linear Weighting: m 0 | p 0.5 | M 1 | Stratific. | Save APS | View APS

Processing Parameters:

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	20
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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4
Ext. DEM	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	Smart 0	N min Gen 50
Scattering Centers	1	Polynomial Order 1	<input type="checkbox"/> Recover		
Matr. Coher. Win	15	15	Weights: <input checked="" type="radio"/> None <input type="radio"/> Coher <input type="radio"/> Amps		

Project Management: Save PRJ | Load PRJ | Export TS | Coher. Thres. 0

SARPROZ (c) 2009-2018, the SAR PROcessor by perizZ | OK

Step 3-7: temporal coherence

Click “plot coher.” to check the temporal coherence for the selected points. The higher the temporal coherence the better is the estimated parameters and APS.

Step 3-8: save parameters

If you are satisfied with the estimated parameters, click “save param.” to save the parameters (velocity, residual height, ...). Click “save coher.” to save the temporal coherence. The red will go away after parameters and coherence are saved.

Multi-Image Sparse Points Processing - /data2/LA_small/

Images Combination
STAR, 1 sensor Images Nr. 64 Conn. Nr. 64 Plot Graph Update Mode

Sparse Points Selection
Parameter Amp. Stab. Index 1-Sig... Thresh. .69 Points Nr: 10923 Not Processed: 10923 All Go Plot Save Load

Reference
Load RefPoint, Sample: 1193 Line: 261

Phase
Save as Read Load APS INV. RES. Save as Read Load

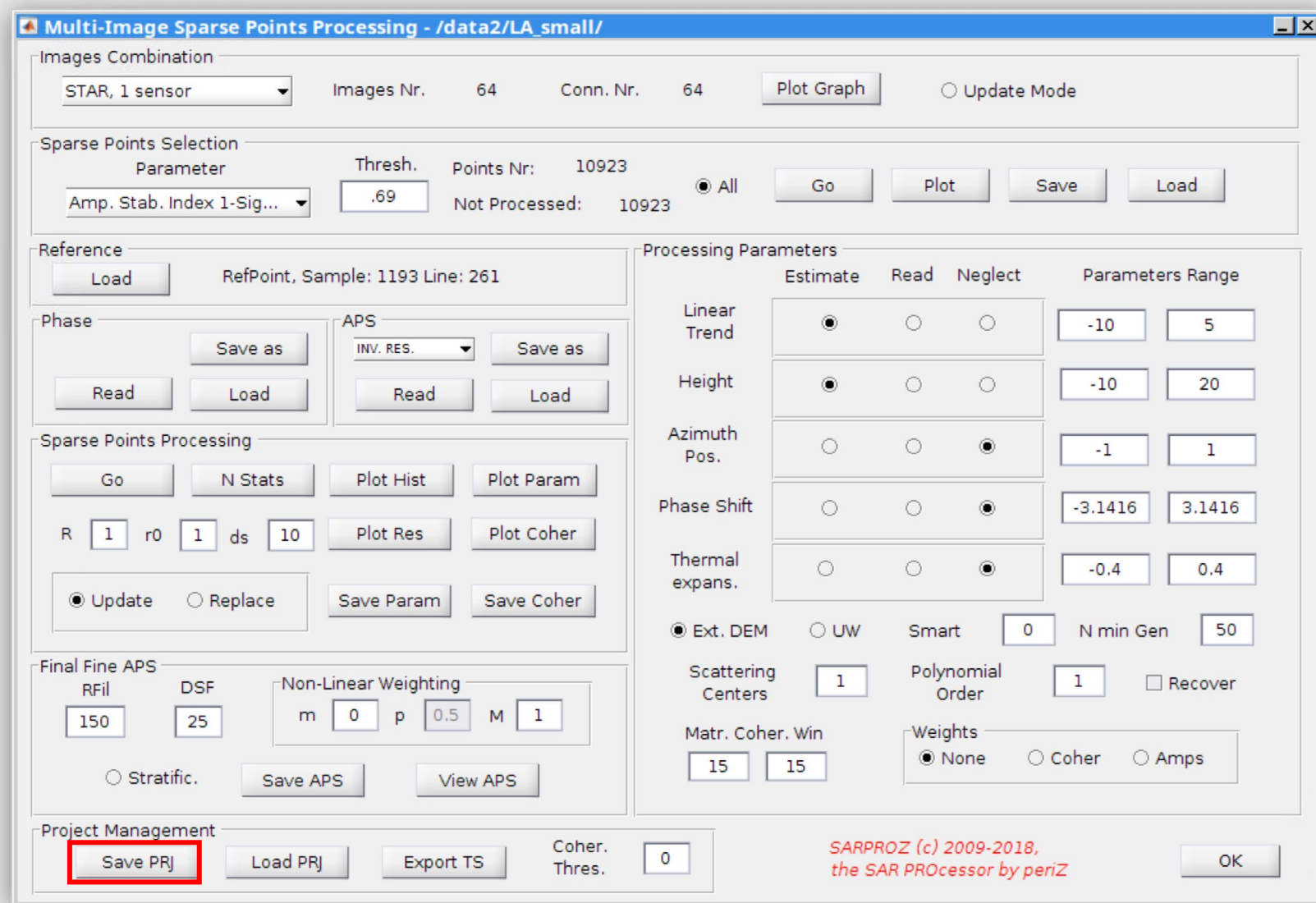
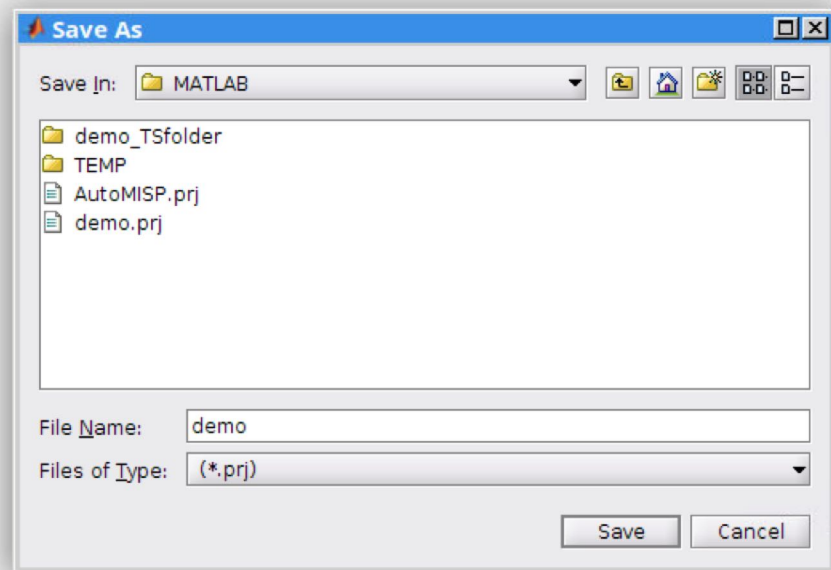
Sparse Points Processing
Go N Stats Plot Hist Plot Param R 1 r0 1 ds 10 Plot Res Plot Coher Update Replace Save Param Save Coher

Final Fine APS
RFil 150 DSF 25 Non-Linear Weighting m 0 p 0.5 M 1 Stratific. Save APS View APS

Processing Parameters
Estimate Read Neglect Parameters Range
Linear Trend -10 5
Height -10 20
Azimuth Pos. -1 1
Phase Shift -3.1416 3.1416
Thermal expans. -0.4 0.4
Ext. DEM UW Smart 0 N min Gen 50
Scattering Centers 1 Polynomial Order 1 Recover
Matr. Coher. Win 15 15 Weights None Coher Amps

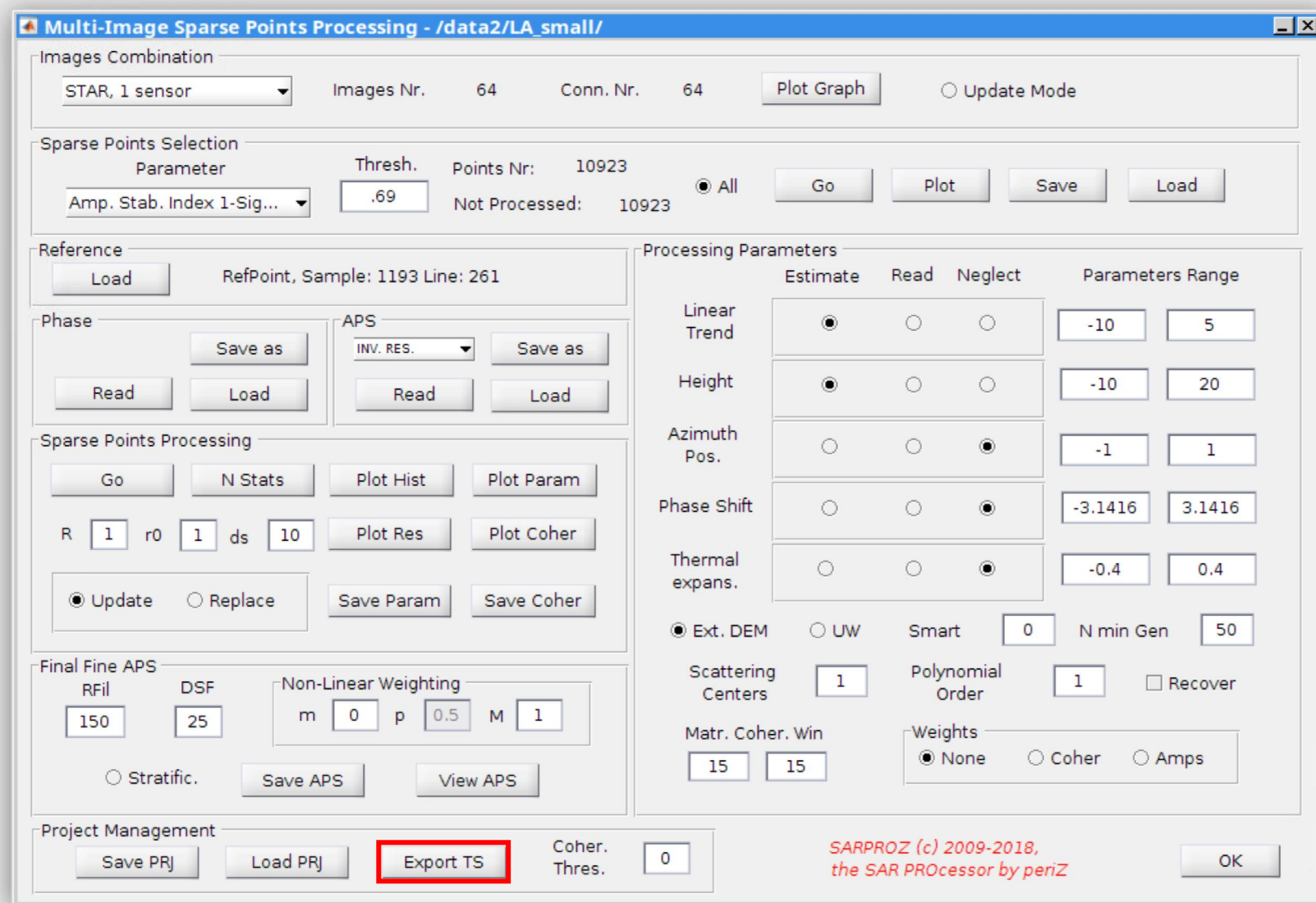
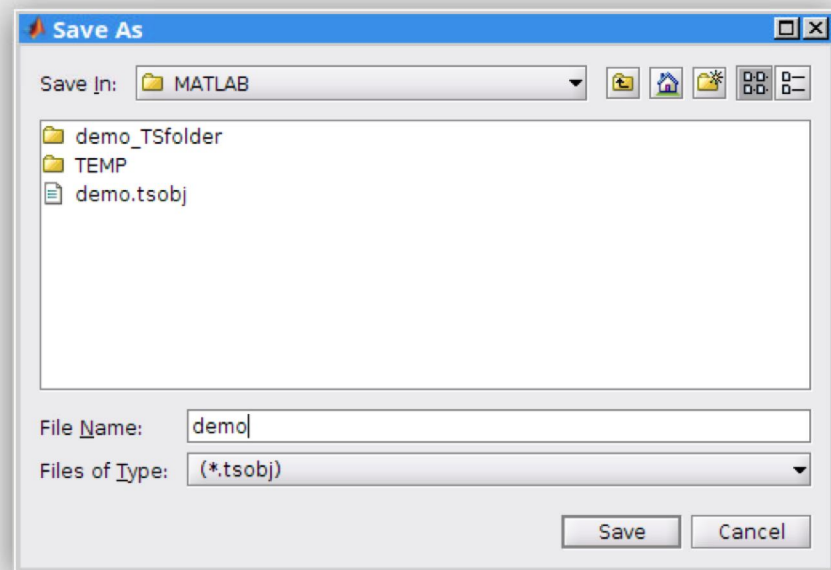
Project Management
Save PRJ Load PRJ Export TS Coher. Thres. 0

SARPROZ (c) 2009-2018, the SAR PROcessor by periz OK



Step 3-9: save project

Click “save prj.” to save the project with your own name. Note that the file extension is “.prj”.



Step 3-10: save time series

Click “export TS” to export the time series with your own filename. We will later use this file to geocode time series to Google Earth. Note that the file extension is “.tsobj”.

```
MATLAB R2016a
HOME PLOTS APPS Search Documentation
Current Folder
writing real file
\data2/LA_small/RESULTS/MATLAB/demo_TSfolder/Time
SeriesCoords26.04.2018.02.19.54 (double)
file /data2/LA_small/RESULTS/MATLAB/demo.tsobj
written
fx >>
```

```
MATLAB R2016a
HOME PLOTS APPS Search Documentation
Current Folder
atmosphere written
Saving file demo-PRJ-Results.mat
results saved
File /data2/LA_small/RESULTS/MATLAB/demo.prj
written
fx >>
```

Step 3-11: Exit

At last, note that when you save something in Sarproz, you will always receive a prompt in the command window. We are now done with this part. Click “ok” to close the module.

Multi-Image Sparse Points Processing - /data2/LA_small/

Images Combination

STAR, 1 sensor

Images Nr. 64Conn. Nr. 64

Plot GraphUpdate Mode

Sparse Points Selection

Parameter

Amp. Stab. Index 1-Sig...

Thresh. .69Points Nr: 10923Not Processed: 10923

AllGoPlotSaveLoad

Reference

LoadRefPoint, Sample: 1193 Line: 261

Phase

Save asReadLoad

APS

INV. RES.

Save asReadLoad

Sparse Points Processing

GoN StatsPlot HistPlot Param

R 1r0 1ds 10Plot ResPlot Coher

UpdateReplaceSave ParamSave Coher

Final Fine APS

Rfil 150DSF 25Non-Linear Weighting

m 0p 0.5M 1

Stratific.Save APSView APS

Project Management

Save PRJLoad PRJExport TS

Coher. Thres. 0

Processing Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	20
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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4
<input checked="" type="radio"/> Ext. DEM <input type="radio"/> UW	Smart	0	N min Gen	50	
Scattering Centers	1	Polynomial Order	1	<input type="checkbox"/> Recover	
Matr. Coher. Win	15	Weights	<input checked="" type="radio"/> None <input type="radio"/> Coher <input type="radio"/> Amps		

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OK

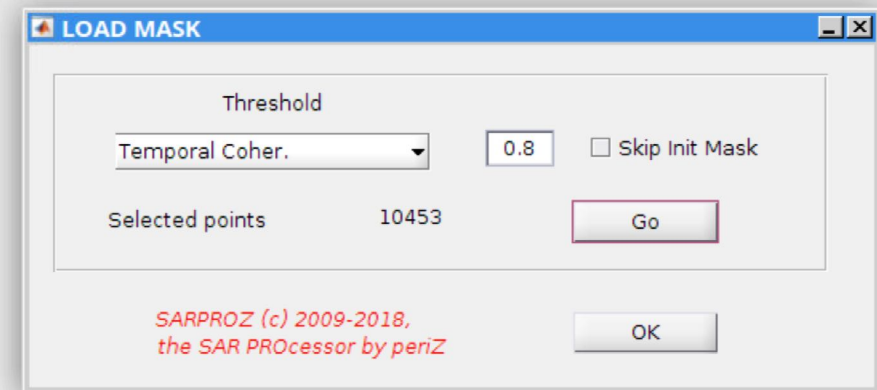
Part 4:

Display the results

Step 4-1: load mask

In this section we will use the “scatter plots” module to quickly check (and export) the results we just processed. The first step is to load an initial number of points to be displayed.

Open “load mask” module from “site processing”. Select “temporal coherence” as the parameter, and select “0.8” as the threshold. Click “go” to calculate the number of points that are above threshold.



Step 4-1: scatter plots

Open “scatter plots” module from “site processing”. The scatter plots module is a powerful module to display results with very flexible options.

SCATTER-PLOTS - /data2/LA_small/

Axes params

Log	Track //	X axis	Repl. +2pi
<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Y axis	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Z axis	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Colour	<input type="checkbox"/>

Actions

Count nr points 10453 C max 5

☐ Rev. Colorbar C min -5

Plot Extract S.A. P dim 6 ReflMap

Save Selection Ampl. Series Mod 0

Boolean sub-selection of points

Track //	Thresholds
<input type="checkbox"/>	<input type="text"/>
& <input type="checkbox"/>	<input type="text"/>
& (<input type="checkbox"/>	<input type="text"/>
& <input type="checkbox"/>	<input type="text"/>
& (<input type="checkbox"/>	<input type="text"/>
& <input type="checkbox"/>	<input type="text"/>
& (<input type="checkbox"/>	<input type="text"/>
& <input type="checkbox"/>	<input type="text"/>
& (<input type="checkbox"/>	<input type="text"/>
& <input type="checkbox"/>	<input type="text"/>

Density

nr bins X nr bins Y Upper saturation

nr bins Z nr bins C Go ☐ Log Diff Hist

Filter / Matrix Visualization / Export

☐ Phase ☒ Transp.

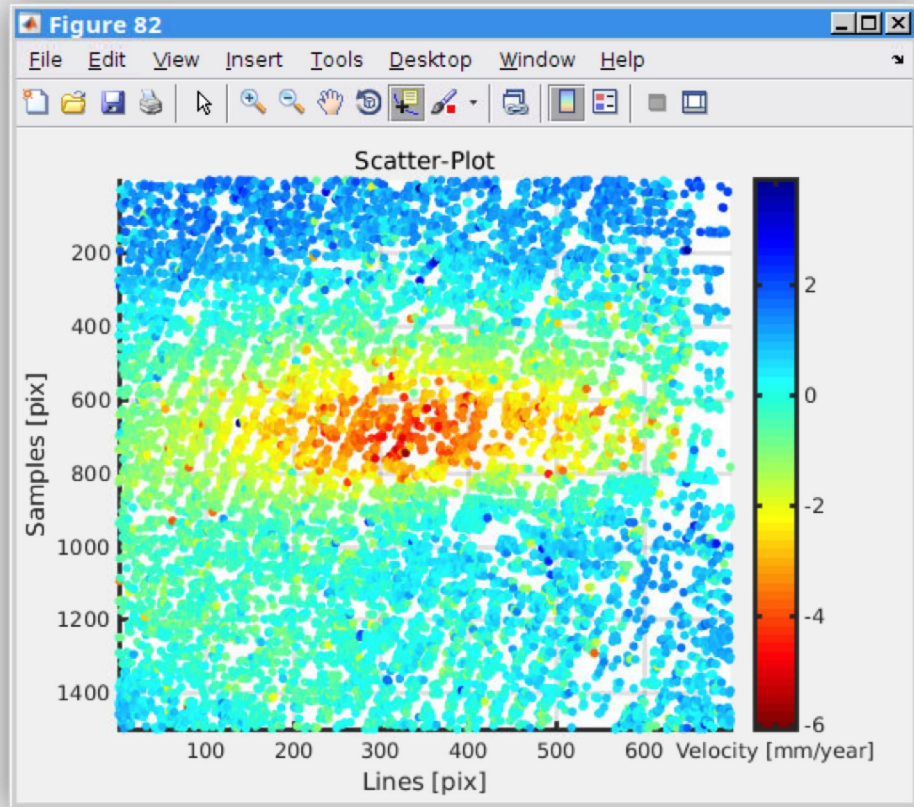
radius d corr downsamp

1 1 10

Go File Type Kml GeoOut

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OK



SCATTER-PLOTS - /data2/LA_small/

Axes params

Log	Track //	X axis	Repl. +2pi
<input type="checkbox"/>	<input type="checkbox"/>	Line	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Sample	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Z axis	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Colour	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Def. trend	<input type="checkbox"/>

Actions

☒ Count nr points 10453 ☐ C max 4 ☐ C min -6

☒ Plot ☐ Rev. Colorbar ☐ Extract S.A. 6 ☐ ReflMap

0

Density

nr bins X nr bins Y Upper saturation

nr bins Z nr bins C ☐ Log

Boolean sub-selection of points

Track //	Thresholds
<input type="checkbox"/>	<input type="text"/>
& <input type="checkbox"/>	<input type="text"/>
& (<input type="checkbox"/>	<input type="text"/>
& <input type="checkbox"/>	<input type="text"/>
& (<input type="checkbox"/>	<input type="text"/>
& <input type="checkbox"/>	<input type="text"/>
& (<input type="checkbox"/>	<input type="text"/>
& <input type="checkbox"/>	<input type="text"/>
& (<input type="checkbox"/>	<input type="text"/>
& <input type="checkbox"/>	<input type="text"/>

Filter / Matrix Visualization / Export

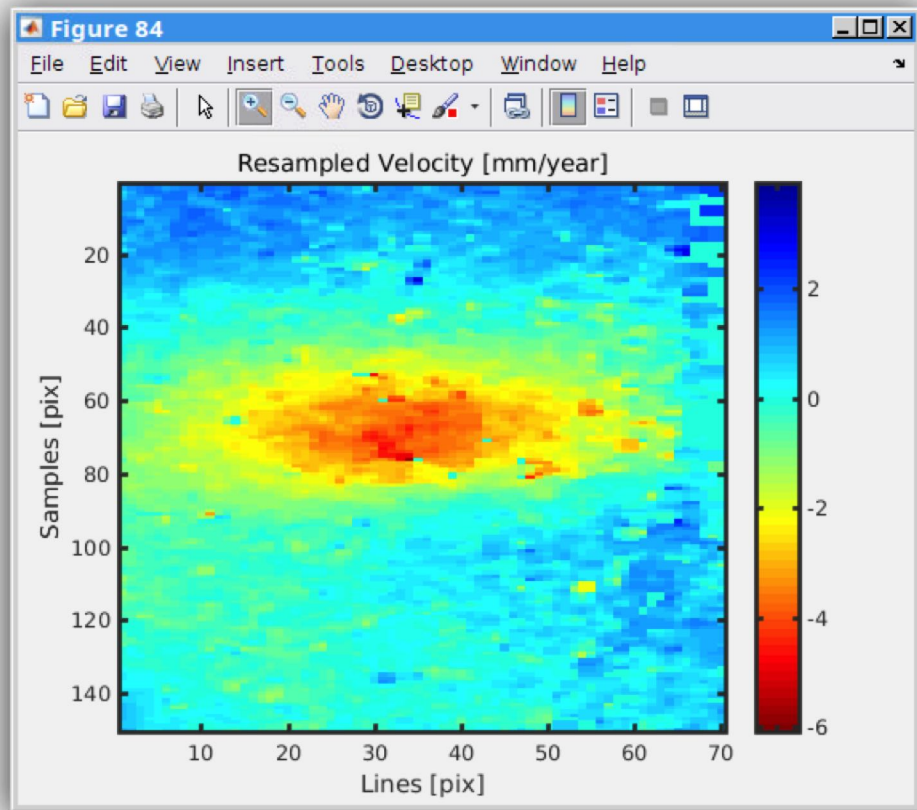
☐ Phase ☒ Transp. radius d corr downsamp

Kml

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Step 4-3: plot

In “axes params.” frame, select “line” for x-axis and “sample” as y-axis and “deformation trend” (velocity) as the color. In “actions” frame, click “count” to count the number of points. Then click “plot” to plot the displacement.



SCATTER-PLOTS - /data2/LA_small/

Axes params

Log	Track //	X axis	Repl. +2pi
<input type="checkbox"/>	<input type="checkbox"/>	Line	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Y axis	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Sample	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Z axis	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Colour	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Def. trend	<input type="checkbox"/>

Actions

Count nr points 10453 C max 4 C min -6

☐ Rev. Colorbar P dim 6 ReflMap

Plot Extract S.A. Save Selection Ampl. Series Mod 0

Boolean sub-selection of points

Track //	Thresholds
<input type="checkbox"/>	
& <input type="checkbox"/>	
& (<input type="checkbox"/>	
& <input type="checkbox"/>	
& (<input type="checkbox"/>	
& <input type="checkbox"/>	
& (<input type="checkbox"/>	
& <input type="checkbox"/>	
& (<input type="checkbox"/>	
& <input type="checkbox"/>	

Density

nr bins X nr bins Y Upper saturation

nr bins Z nr bins C Go ☐ Log Diff Hist

Filter / Matrix Visualization / Export

☐ Phase ☒ Transp. radius d corr downsamp

1 1 10

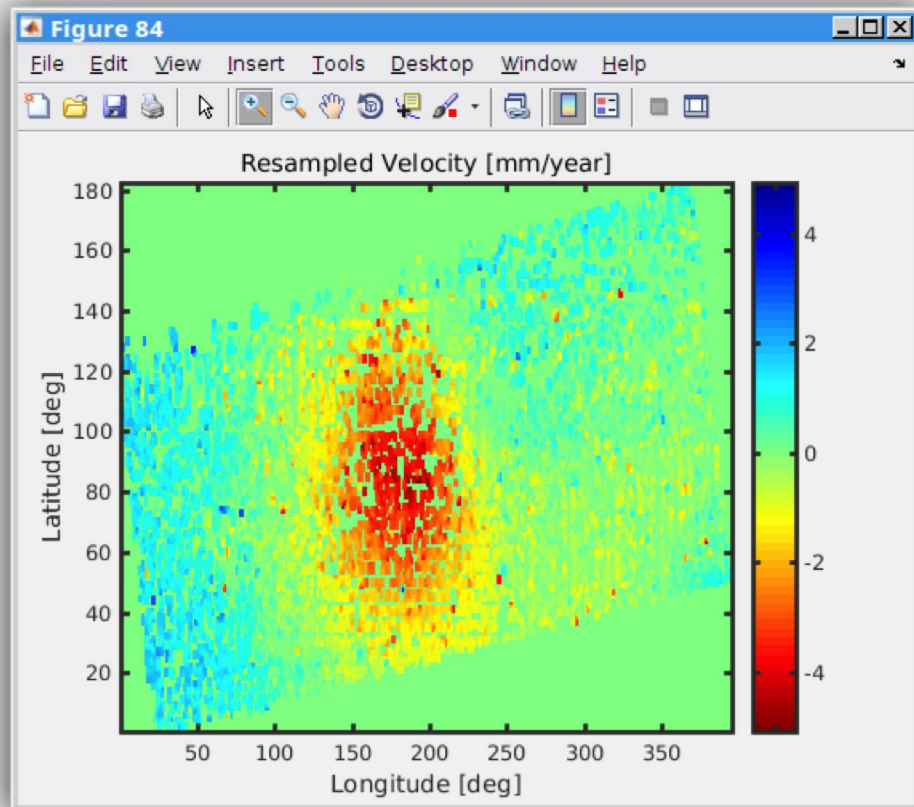
Go File Type Kml GeoOut

OK

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Step 4-3 (cont'd)

You can also click “go” in the “filter/matrix visualization/export” frame to view the results in matrix and down sampled way, instead of the scatter plot.



SCATTER-PLOTS - /data2/LA_small/

Axes params

Log	Track //	X axis	Repl. +2pi
<input type="checkbox"/>	<input type="checkbox"/>	Longitude	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Latitude	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Colour	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	Def. trend	<input type="checkbox"/>

Actions

Count nr points 10453 C max 5 C min -5

☐ Rev. Colorbar P dim 6 ReflMap

Plot Extract S.A. Save Selection Ampl. Series Mod 0

Density

nr bins X nr bins Y Upper saturation

nr bins Z nr bins C Go ☐ Log Diff Hist

Boolean sub-selection of points

Track // Thresholds

Filter / Matrix Visualization / Export

☐ Phase ☒ Transp. radius d corr downsamp

1 1 10

File Type

Go Kml GeoOut

OK

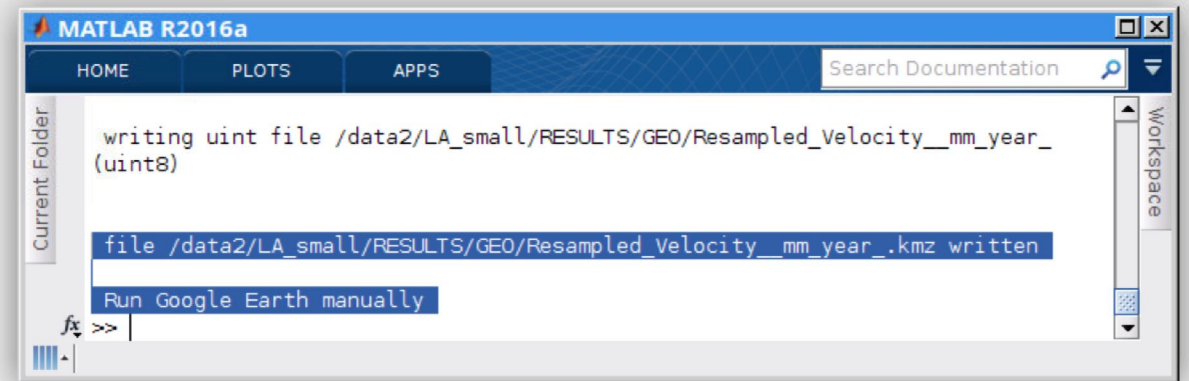
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Step 4-4: geocode to Google Earth

If you wish to geocode this result to Google Earth, you need to select “longitude” as x-axis and “latitude” as y-axis. Then click “go” again to see the result in lat/lon coordinate. At last, click “GeoOut” to export the result in .kmz format.

Step 4-4 (cont'd)

If your Google Earth does not open automatically, locate the .kmz file path as shown in the Matlab command window and run Google Earth manually.



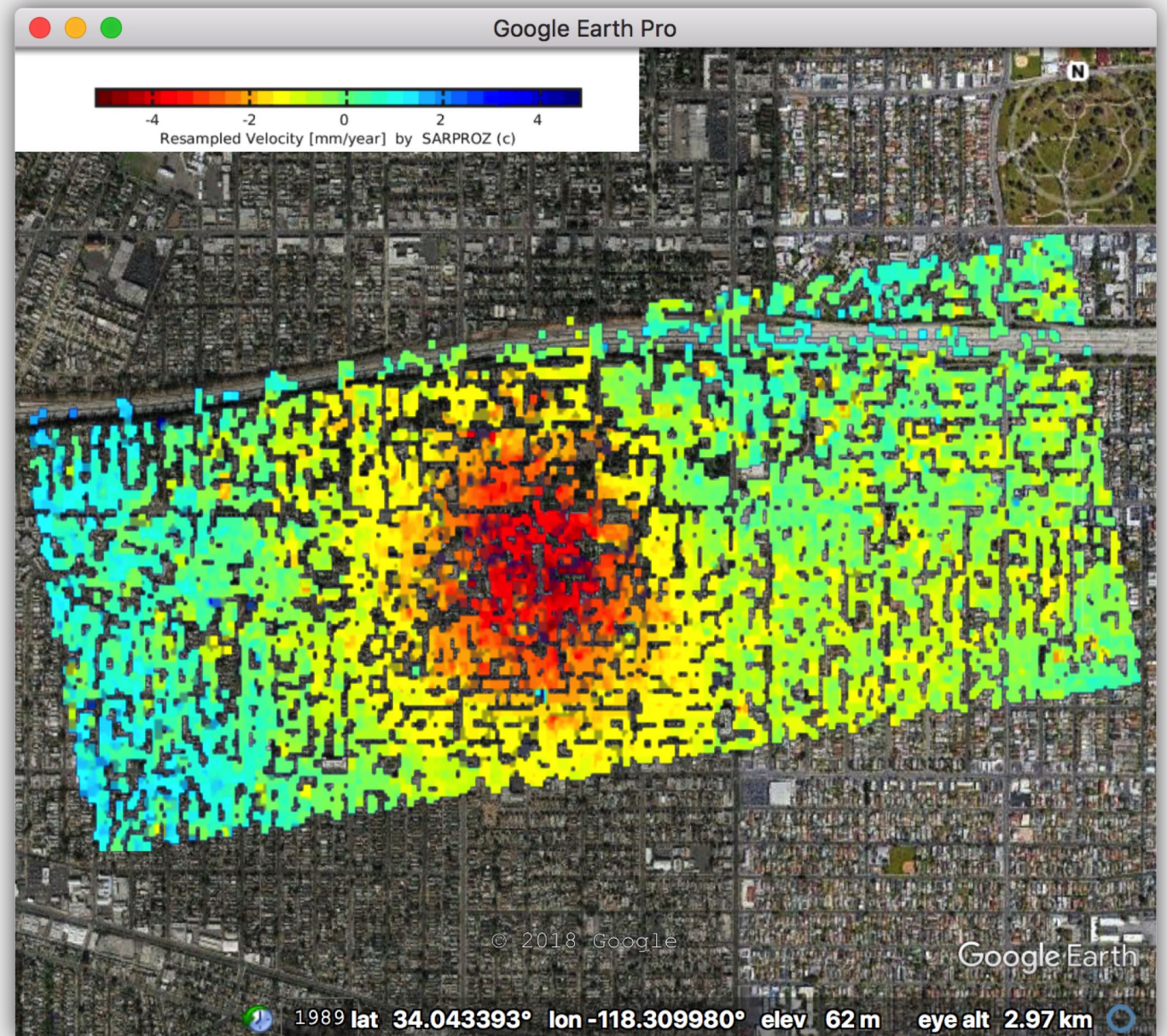
The image shows a MATLAB R2016a window with the 'HOME' tab selected. The command window displays the following text:

```
writing uint file /data2/LA_small/RESULTS/GEO/Resampled_Velocity__mm_year_  
(uint8)  
  
file /data2/LA_small/RESULTS/GEO/Resampled_Velocity__mm_year_.kmz written  
  
Run Google Earth manually
```

The command prompt is at the bottom, showing the MATLAB logo and the prompt characters '»'.

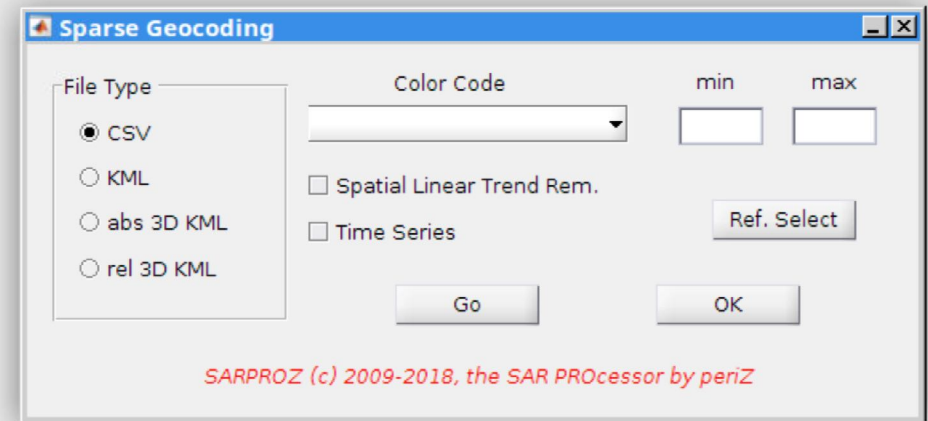
Step 4-5: open Google Earth

Open the kmz file in Google Earth. Please note that in step 4-4, we specified the color range with a symmetric interval $([-5, 5])$, so that here the green color means zero velocity.



Step 4-6: sparse geocoding

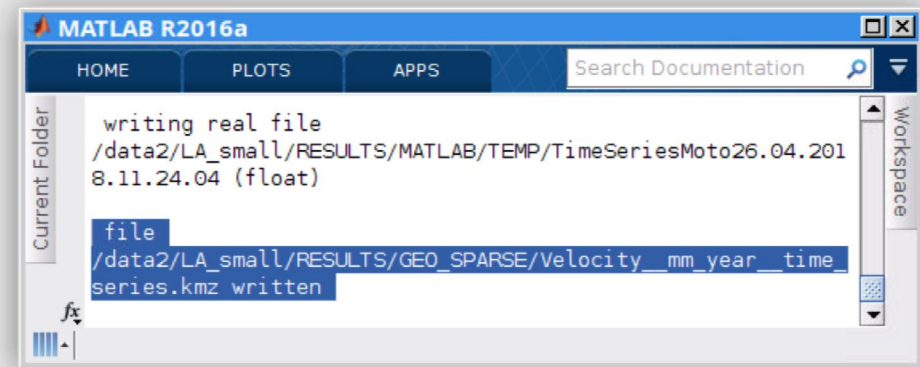
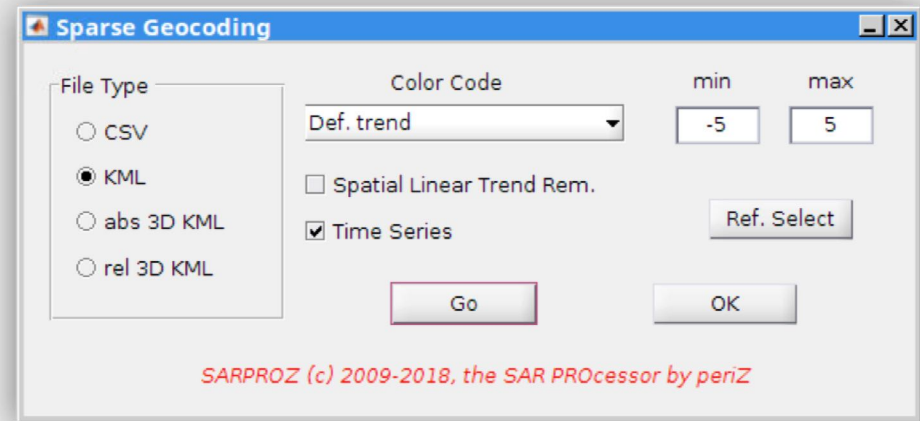
In addition, you can quickly export the the results you have just processed in section 3 with the “sparse geocoding” module. You can open this module from “site processing”. Note that this module will only export the most recent parameters you have estimated in “sparse points processing” module. We recommend you to use the “time series module” for exporting results because it is more powerful and comes with more options (the “time series module will be introduced in the next section”).



Step 4-6 (cont'd)

You can choose here to export your results in csv format or kml format. Here we choose to export “deformation trend” with a symmetric range of $[-5, 5]$ (mm/year). We tick “time series” so that the time series of points will be shown in Google Earth. Click “go” to export. Again, if Google Earth does not open automatically, check the prompt in the command window for the file path and open it manually.

The final results are shown in the next section.



Part 5:

Geocode Time Series

Step 5-1: time series module

In this section we introduce a more powerful module for exporting time series. Open “time series module” from “site processing”.

Time Series Module - /data2/LA_small/

Current Dataset: Images Graph: One-sensor STAR Nr of Images: 64 Nr of Points: 10453

Time Series Preparation

Phase: none

APS: INV. RES. none

TS object: none Ref: none

Geolocation corrections: North 0 East 0 Height 0

Post-Selection: Coh. Thr. 0 Nr Pts:

Sparse TS Geocoding

Color Code Min Max

File Type: Csv

Time Series Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	-10	5
Height	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	-10	20
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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4

☒ Ext. DEM ☐ UW Smart 0 N min Gen 50

Scattering Centers 1 Polynomial Order 1 ☐ Recover

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

Time Series Space Visualization and Export

Reference: Date Bn DC Bt Id Temp Target: Date Bn DC Bt Id Temp Min Max

Value: Mod+Res Conversion: Displ. [mm] Coords.: Geog. View: Resampled Msiz: 4 R: 1 r0: 1 ds: 10 File Type: Kml

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Step 5-2: load tsobj

Click “load” in the “time series preparation” frame. Load the .tsobj file you saved in step 3-10. When the file is loaded you can see the information (filename, reference point) in the frame.

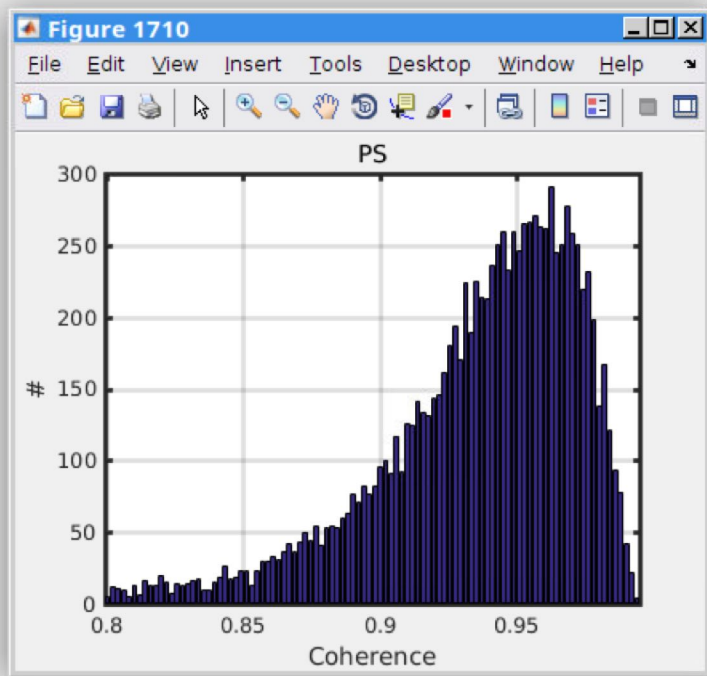
The screenshot shows the 'Time Series Module' window with the title bar '/data2/LA_small/'. The interface is divided into several sections:

- Current Dataset:** Images Graph: One-sensor STAR, Nr of Images: 64, Nr of Points: 10923.
- Time Series Preparation:**
 - Phase:** Load button, none.
 - APS:** INV. RES. dropdown, Load button, none.
 - TS object:** demo.tsobj, Ref: id=4254, s=1193, l=261 (highlighted with a red box).
 - Geolocation corrections:** North 0, East 0, Height 0, Go button.
 - Post-Selection:** Coh. Hist. button, Coh. Thr. 0, Go button, Nr Pts: 10923.
 - Sparse TS Geocoding:** Color Code dropdown, Min/Max input fields, Ref Kml button, File Type: Csv, Go button.
- Time Series Parameters:**

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	20
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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4
<input checked="" type="radio"/> Ext. DEM <input type="radio"/> UW Smart 0 N min Gen 50					
Scattering Centers	1		Polynomial Order	1 <input type="checkbox"/> Recover	
Matr. Coher. Win	15 15		Weights <input checked="" type="radio"/> None <input type="radio"/> Coher <input type="radio"/> Amps		
- Time Series Space Visualization and Export:**
 - Reference: Date Bn DC Bt Id Temp, Target: Date Bn DC Bt Id Temp, Min/Max input fields.
 - Value: Mod+Res, Conversion: Displ. [mm], Coords.: Geog., View: Resampled, Msiz: 4, R: 1, r0: 1, ds: 10, View button.
 - File Type: Kml, Export button.

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OK



Step 5-3: select points

You can also set a threshold to specify the points you want to export. Here we use “0.8” as the threshold of temporal coherence. Click “go” to count the number of points. Click “Coh. Hist.” to check the histogram after thresholding.

Time Series Module - /data2/LA_small/

Current Dataset: Images Graph: One-sensor STAR Nr of Images: 64 Nr of Points: 10923

Time Series Preparation

Phase: none

APS: none

TS object: demo.tsobj Ref: id=4254, s=1193, l=261

Geolocation corrections: North East Height

Post-Selection

Sparse TS Geocoding

Color Code: Min:

File Type: Max:

Time Series Parameters

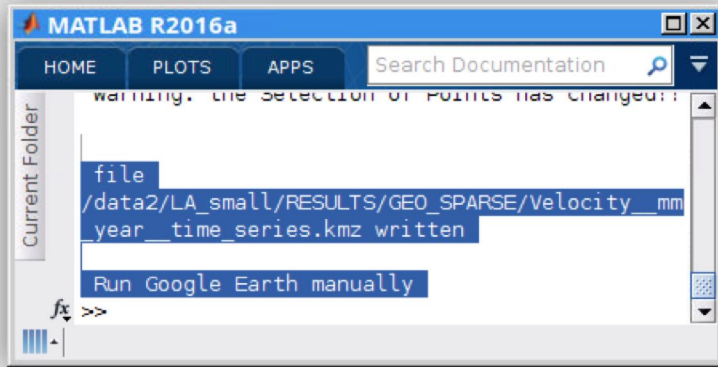
	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	20
Azimuth Pos.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-1	1
Phase Shift	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4
<input checked="" type="radio"/> Ext. DEM <input type="radio"/> UW Smart <input type="text" value="0"/> N min Gen <input type="text" value="50"/>					
Scattering Centers	<input type="text" value="1"/>		Polynomial Order	<input type="text" value="1"/> <input type="checkbox"/> Recover	
Matr. Coher. Win	<input type="text" value="15"/> <input type="text" value="15"/>		Weights: <input checked="" type="radio"/> None <input type="radio"/> Coher <input type="radio"/> Amps		

Time Series Space Visualization and Export

Reference: Target: Min: Max:

Value: Conversion: Coords.: View: Msiz: R: r0: ds: File Type:

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Step 5-4: geocoding

In “sparse TS geocoding” frame, select “deformation trend” as color code, “kml” as the file type. Use a symmetric color range, [-5, 5]. Then click “go” to export the time series.

Time Series Module - /data2/LA_small/

Current Dataset: Images Graph: One-sensor STAR Nr of Images: 64 Nr of Points: 10923

Time Series Preparation

Phase: none

APS: INV. RES. none

TS object: demo.tsobj Ref: id=4254, s=1193, l=261

Geolocation corrections: North East Height

Post-Selection: Coh. Hist. Coh. Thr. Nr Pts: 10451

Sparse TS Geocoding

Color Code: Def. trend Min:

File Type: Kml Max:

Time Series Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	20
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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4

☒ Ext. DEM ☐ UW Smart N min Gen

Scattering Centers Polynomial Order ☐ Recover

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

Time Series Space Visualization and Export

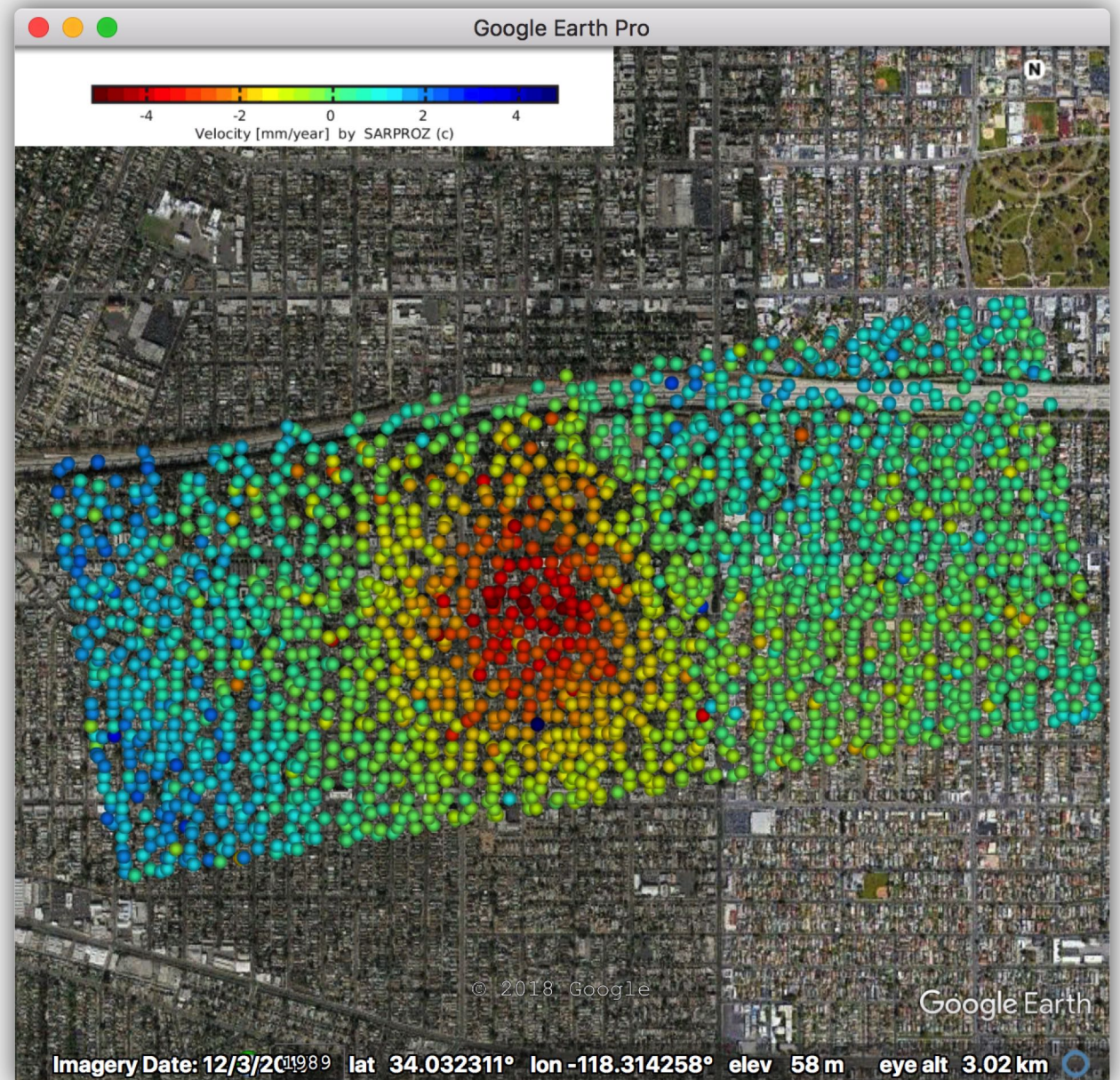
Reference: Date Bn DC Bt Id Temp Target: Date Bn DC Bt Id Temp Min: Max:

Value: Mod+Res Conversion: Displ. [mm] Coords.: Geog. View: Resampled Msiz: 4 R: 1 r0: 1 ds: 10 File Type: Kml

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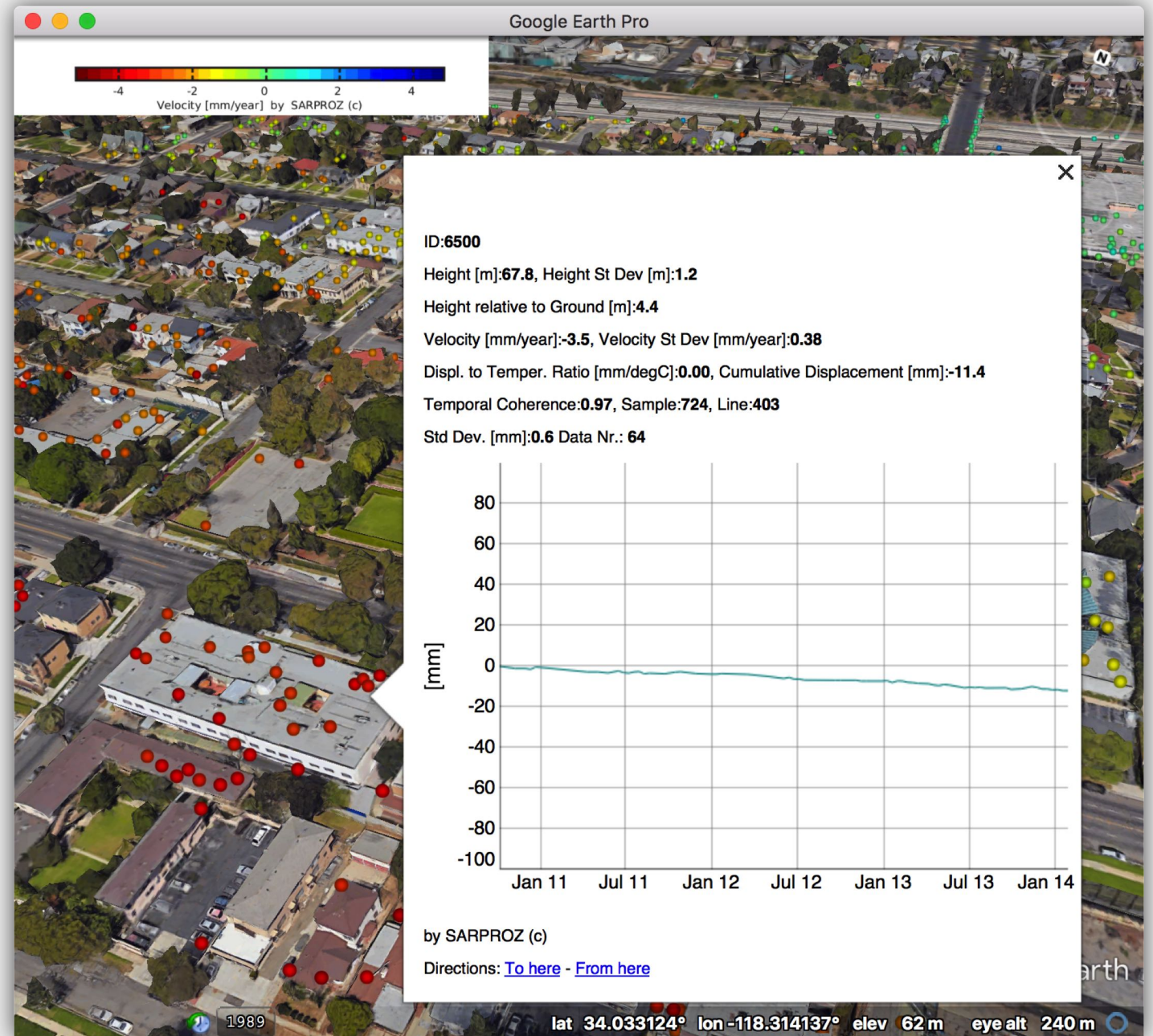
Step 5-5: open Google Earth

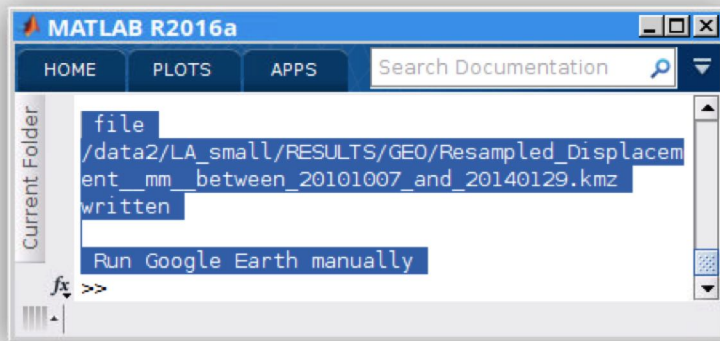
Open the `velocity__mm_year__time_series.kmz` file in Google Earth.



Step 5-6: check time series

You can zoom in, click on any points, check the time series of that point along with other parameters, such as residual height, velocity, temporal coherence, etc.





Step 5-7: time series space visualization and export

In “time series space visualization and export” frame, you can check the displacement between any two given dates. For example, select 2010-10-07 as the reference date, and 2014-01-29 as the target date. Keep other options as their default values. Click “view” to view in Sarproz and click “Export” to geocode the result to Google Earth.

Time Series Module - /data2/LA_small/

Current Dataset: Images Graph: One-sensor STAR Nr of Images: 64 Nr of Points: 10923

Time Series Preparation

Phase: Load none

APS: INV. RES. Load none

TS object: demo.tsobj Ref: id=4254, s=1193, l=261

Geolocation corrections

North 0 East 0 Height 0 Go

Load Ref Go Load Save as

Post-Selection

Coh. Hist. Coh. Thr. 0.8 Go Nr Pts: 10451

Sparse TS Geocoding

Color Code Def. trend Min -5 Ref Kml

File Type Kml Max 5 Go

Time Series Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	5
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	20
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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4

☒ Ext. DEM ☐ UW Smart 0 N min Gen 50

Scattering Centers 1 Polynomial Order 1 ☐ Recover

Matr. Coher. Win 15 15

Weights ☒ None ☐ Coher ☐ Amps

Time Series Space Visualization and Export

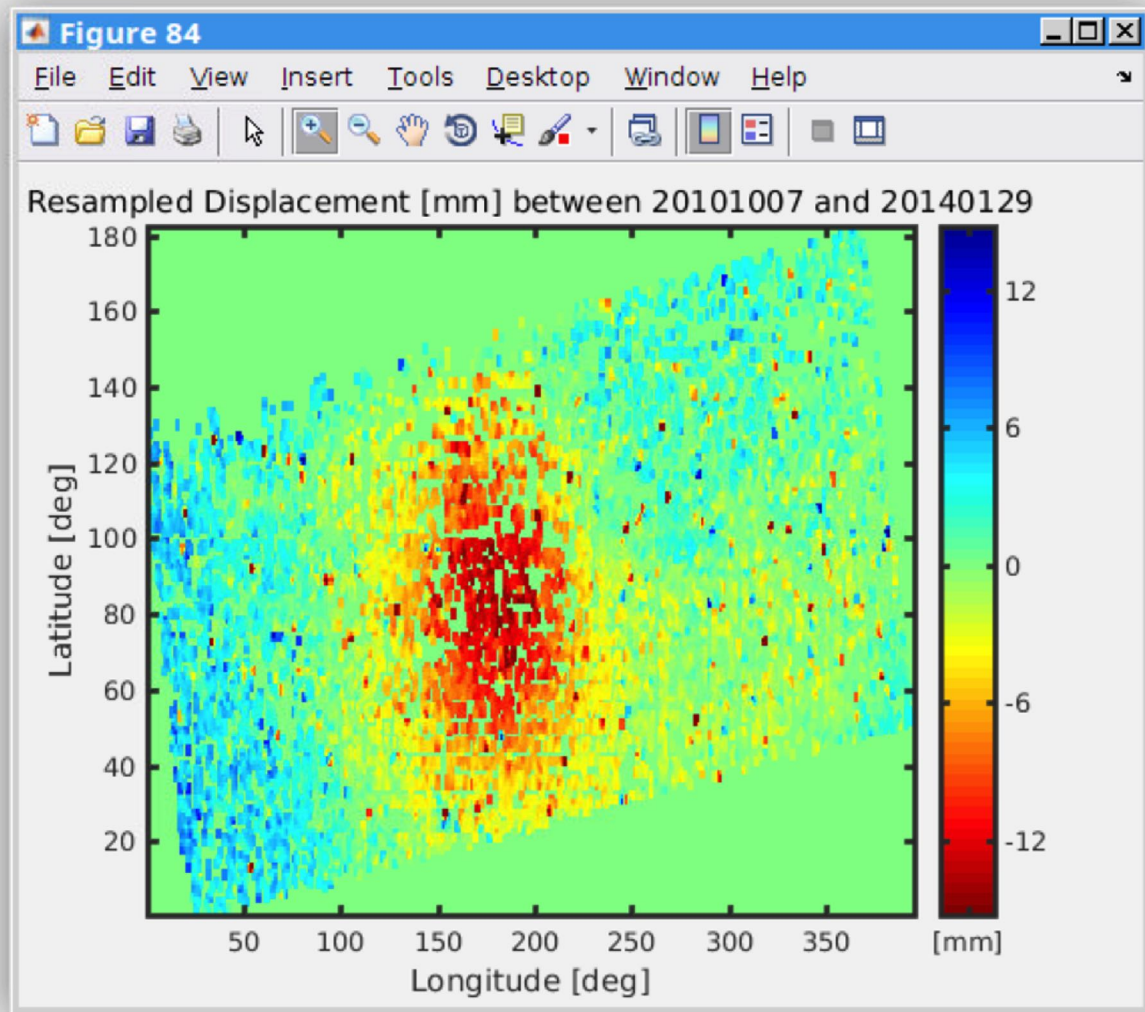
Reference 20101007 -3 0.00 -715 51 18... Target 20140129 -27 0.01 495 51 16... Min -15 Max 15

Value	Conversion	Coords.	View	Msiz	R	r0	ds	File Type
Mod+Res	Displ. [mm]	Geog.	Resampled	4	1	1	10	Kml

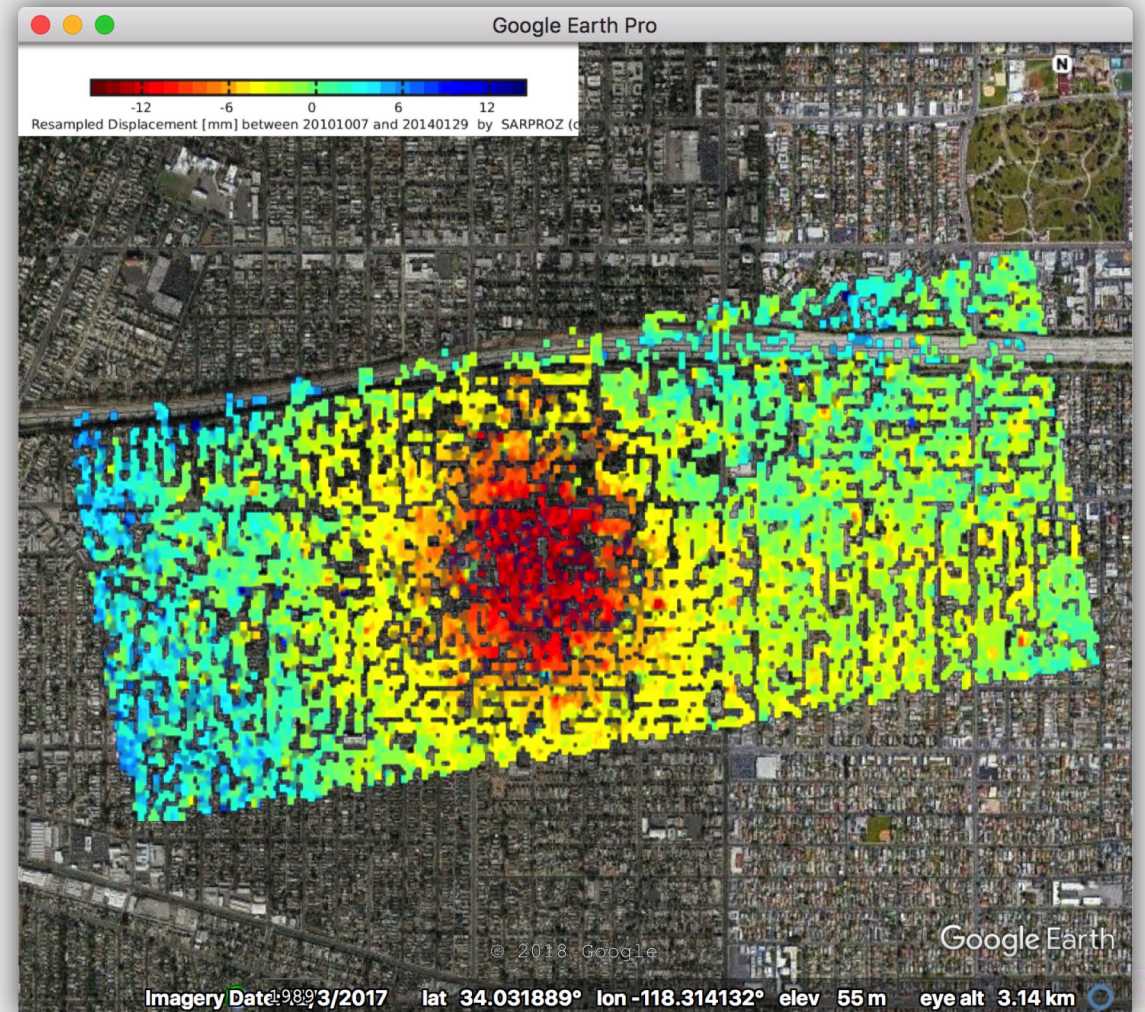
View Export

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OK



Resampled displacement figure in Sarproz



Resampled displacement geocoded to Google Earth

Appendix A:

Estimate non-linear movement

Estimating non-linear movement

- Sometimes the ground movement might not always be linear. In such case where it is not the best to use a linear model, the software also provides a way to estimate non-linear movement:
 - In “APS estimation” and “sparse point processing”, instead of checking “estimate” for linear trend, check “neglect” for “linear trend”, and put down “5” in the “smart” option box.
 - The rest of the steps are identical.
- An application with the non-linear model could be find [here](#).

Step A-1: use “smart” in APS

To use a non parametric model for movement estimation, choose “neglect” for “linear trend” and put down “5” in “smart” box for step 2-4. Other steps remain the same.

The screenshot shows the APS Processing software interface with the following settings:

- Images Combination:** STAR, 1 sensor. Images Nr: 64, Conn. Nr: 64, Missing APS: 0. Update Mode and APS pre-removal are unchecked.
- Sparse Points Selection:** Parameter: Amp. Stab. Index 1-Sigm..., Thresh.: 0.85, DS: 20, DL: 0, PSC Nr: 494. Go, Plot, Save, and Load buttons are visible.
- Graph Creation:** Delaunay. Min Nr: 10, Min R: 30, Max R: Inf. Go, Plot, Save, and Load buttons are visible.
- Processing Parameters:**

	Estimate	Read	Neglect	Parameters Range
Linear Trend	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-100 to 100
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-20 to 20
Azimuth Pos.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-1 to 1
Phase Shift	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-3.1416 to 3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4 to 0.4

Ext. DEM (selected), UW, Smart (selected), 5, N min Gen: 50, Scattering Centers: 1, Polynomial Order: 1, Recover (unchecked), Matr. Coher. Win: 15, 15, Weights: None (selected), Coher, Amps.
- Connections processing:** Go, Save As, Clear Diff, Load buttons.
- Connections coherence:** Hist, Plot Graph, N Stats buttons. Non-Linear Weighting: m: 0.74, p: 0.86, M: 0.97, Plot button.
- Reference Point:** Auto, Go, Plot buttons. Nr: 0, <, > buttons.
- Estimated Parameters:** Plot, R: 1, r0: 1, ds: 10, Flatten (unchecked), Optional: Save, Export TS buttons.
- APS options:** Type: Inverted Residuals, Stratif. (unchecked), R: 150, DSF: 25.
- APS Estimate:** Go, Plot, Test, OK buttons.

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Step A-2: use “smart” in MISp

Multi-Image Sparse Points Processing - /data2/LA_small/

Images Combination
STAR, 1 sensor Images Nr. 64 Conn. Nr. 64 Plot Graph Update Mode

Sparse Points Selection
Parameter Amp. Stab. Index 1-Sig... Thresh. .69 Points Nr: 10923 Not Processed: 0 All Go Plot Save Load

Reference
Load None

Phase
Save as Read Load APS INV. RES. Save as Read Load

Sparse Points Processing
Go N Stats Plot Hist Plot Param R 1 r0 1 ds 10 Plot Res Plot Coher Update Replace Save Param Save Coher

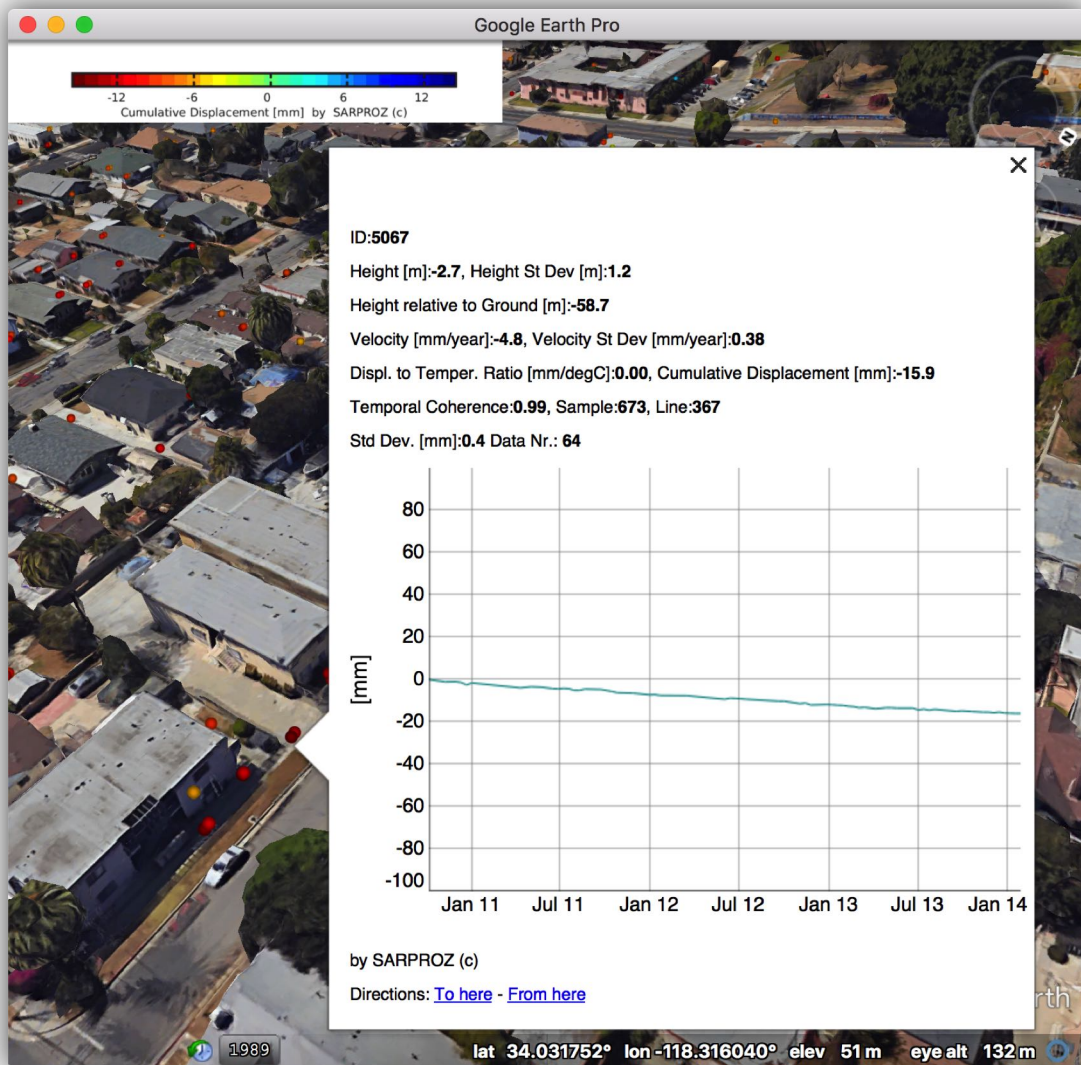
Final Fine APS
Rfil 150 DSF 25 Non-Linear Weighting m 0 p 0.5 M 1 Stratific. Save APS View APS

Project Management
Save PRJ Load PRJ Export TS Coher. Thres. 0

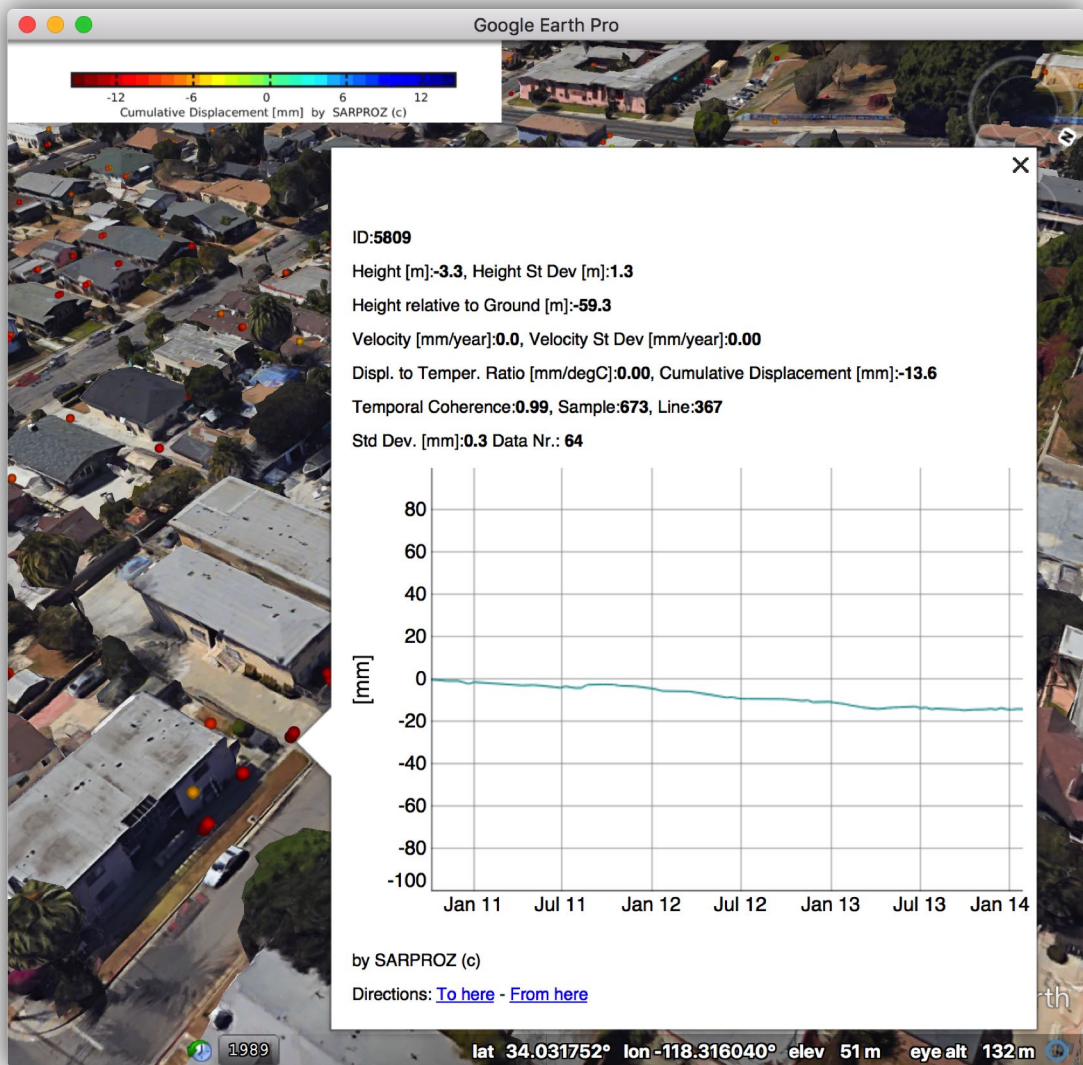
Processing Parameters

	Estimate	Read	Neglect	Parameters Range	
Linear Trend	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-100	100
Height	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	-10	20
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"/>	-3.1416	3.1416
Thermal expans.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	-0.4	0.4
Ext. DEM	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	Smart	5
UW	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	N min Gen	50
Scattering Centers	1	Polynomial Order	1	Recover	
Matr. Coher. Win	15	15	Weights	<input checked="" type="radio"/> None <input type="radio"/> Coher <input type="radio"/> Amps	

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One example using the linear model.



One example using the “smart” model. Note that the velocity is “0” because we did not estimate velocity.

Bye