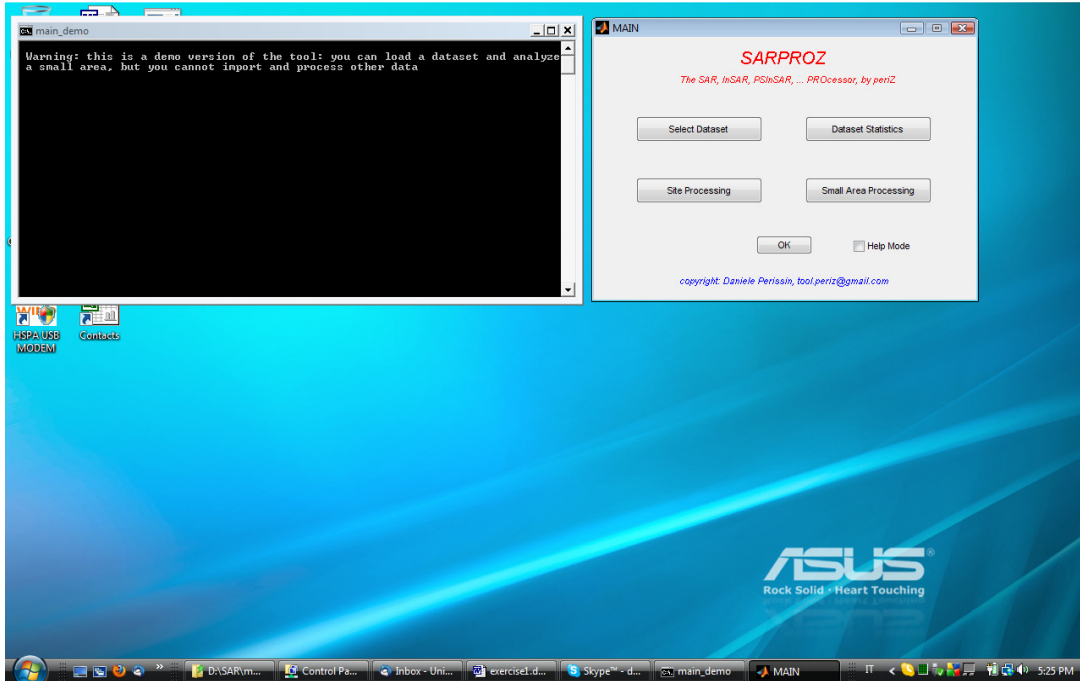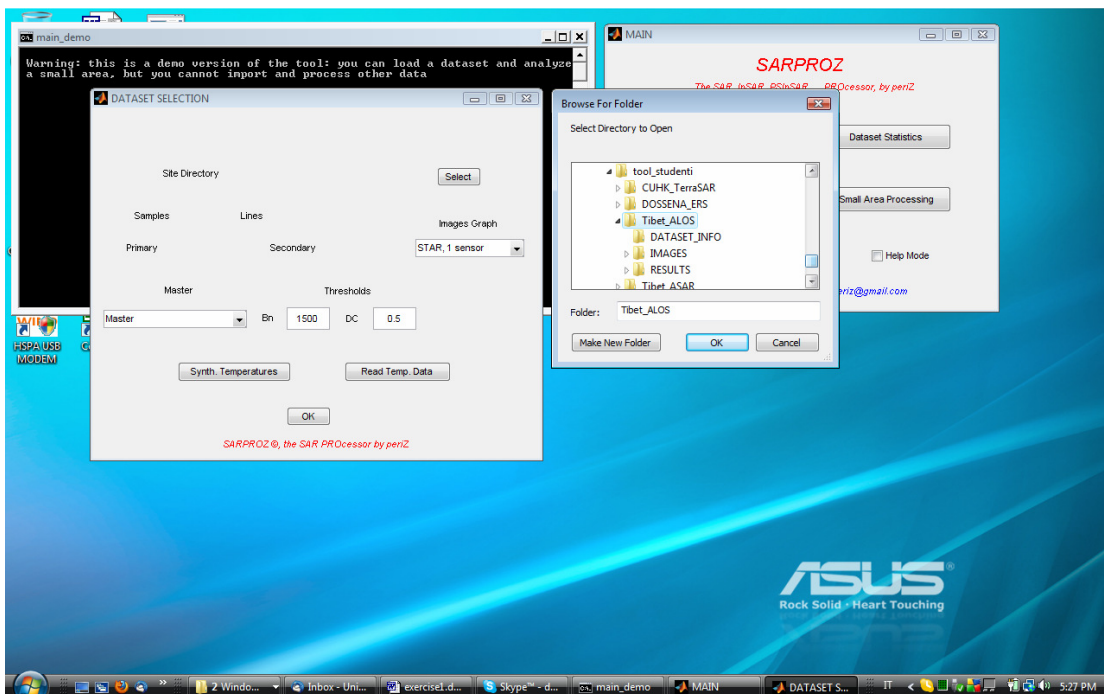# 1.0 SAR interferometry

1. Run the tool by double clicking the executable file main_demo.exe


2. Select the dataset to process by clicking on "Select Dataset" and consequently "Select", then choose the directory "Tibet_ALOS"

3. From the window "Dataset Selection", put the Threshold on Normal Baselines equal to 4000m (ALOS has higher Normal Baselines than other sensors) and then click OK.
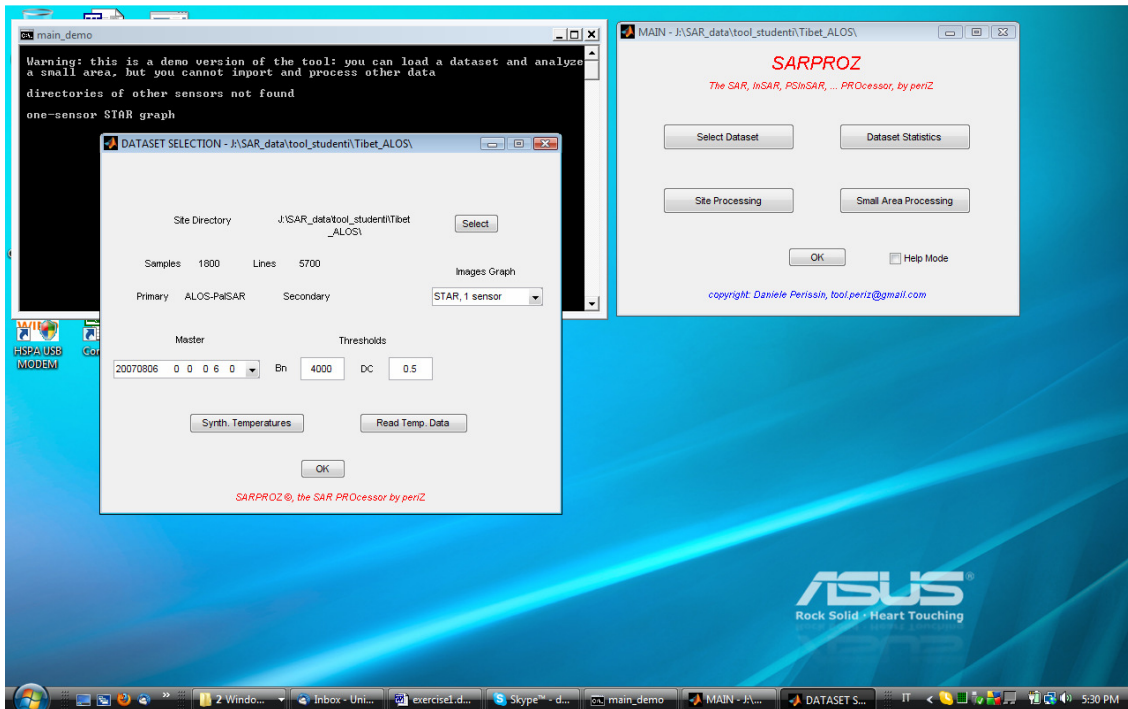

4. you can view the parameters of the selected images by launching "Dataset Statistics"
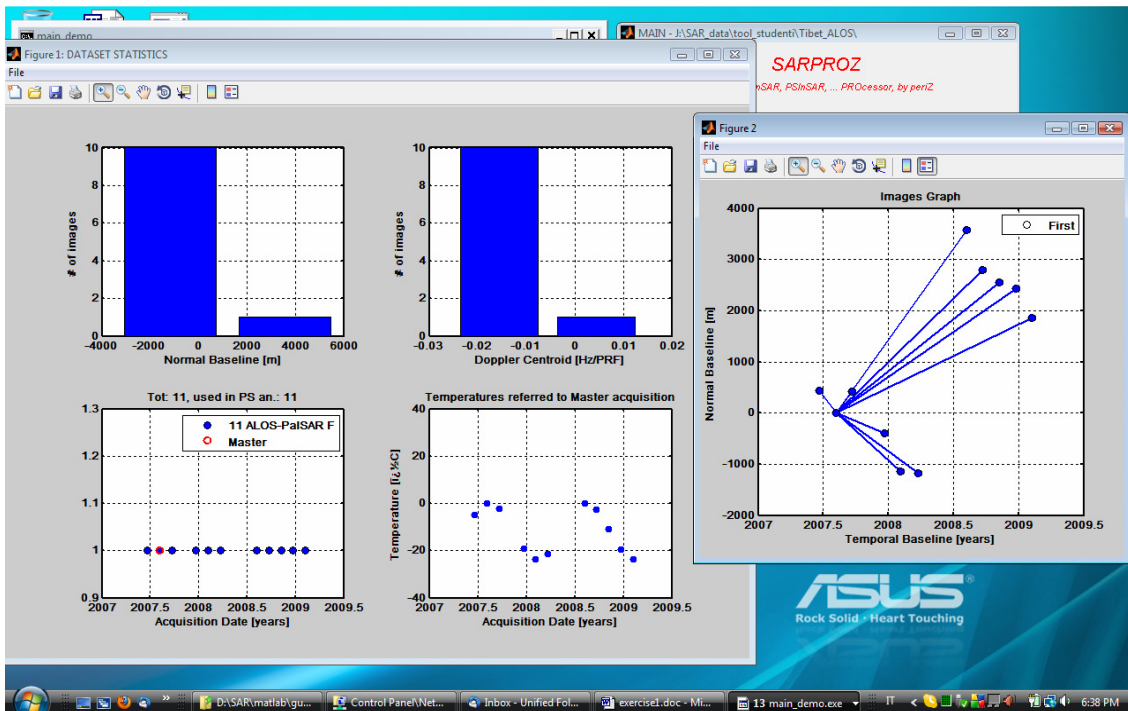

Two images will be displayed, with the following parameters:

Histogram of Normal Baselines, Histogram of Doppler Centroids (as a function of PRF), acquisitions time series, simulated temperatures time series, graph connecting the images represented in the Normal-Temporal baselines space.
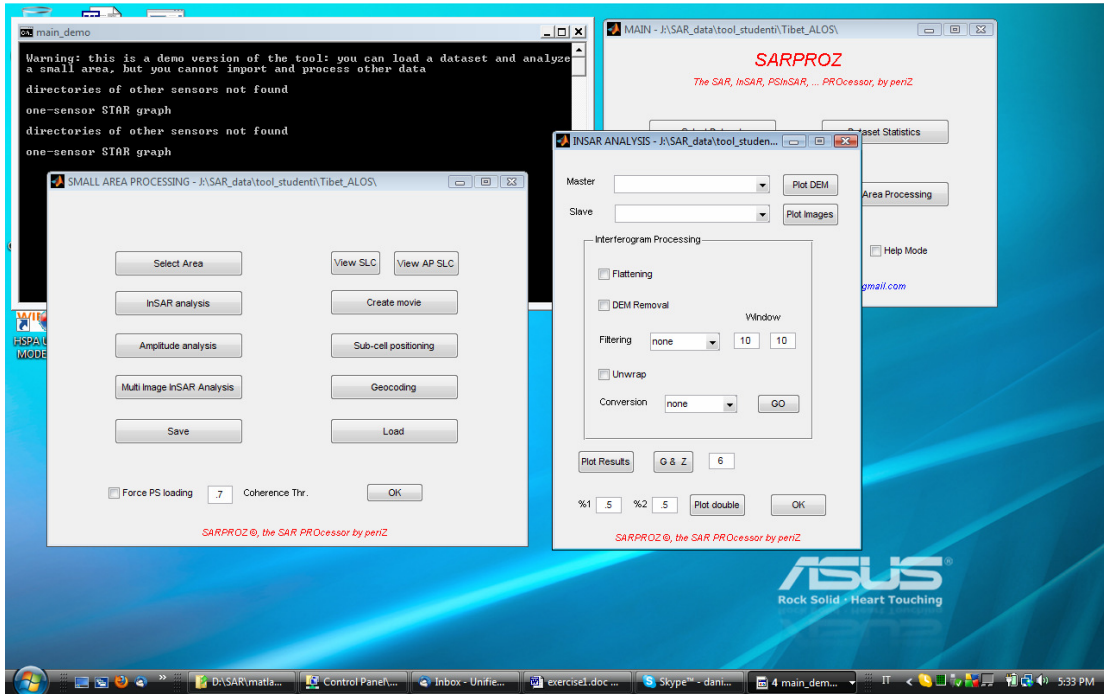
5. By clicking on "Small Area processing" from the Main window the following figure will appear:
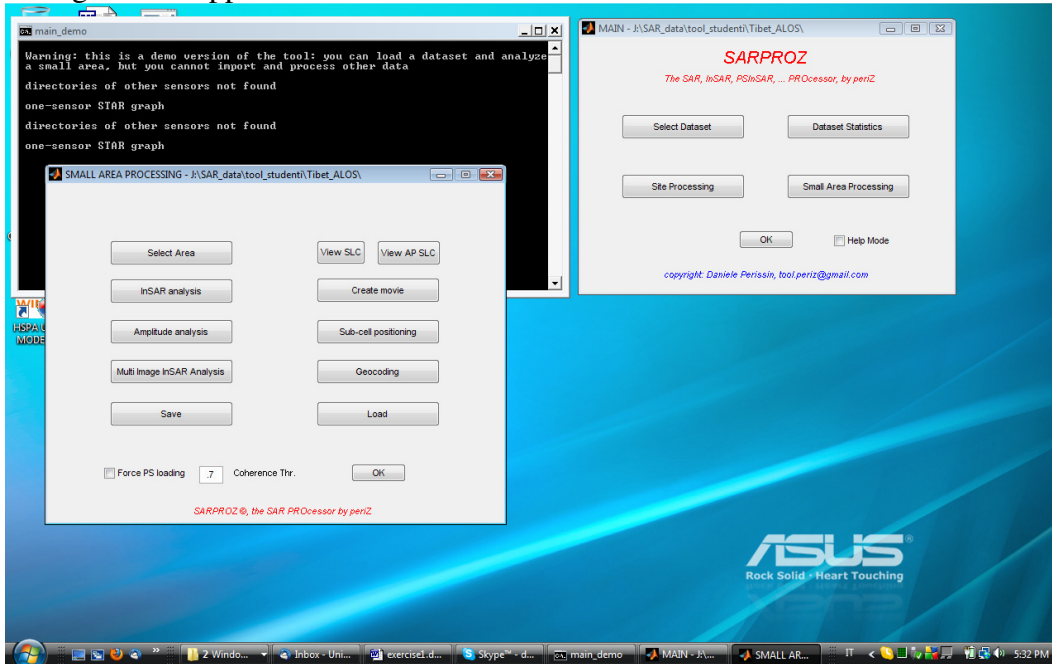
6. Click on "Load" to choose a previously saved set of data, and select "relief.mat"
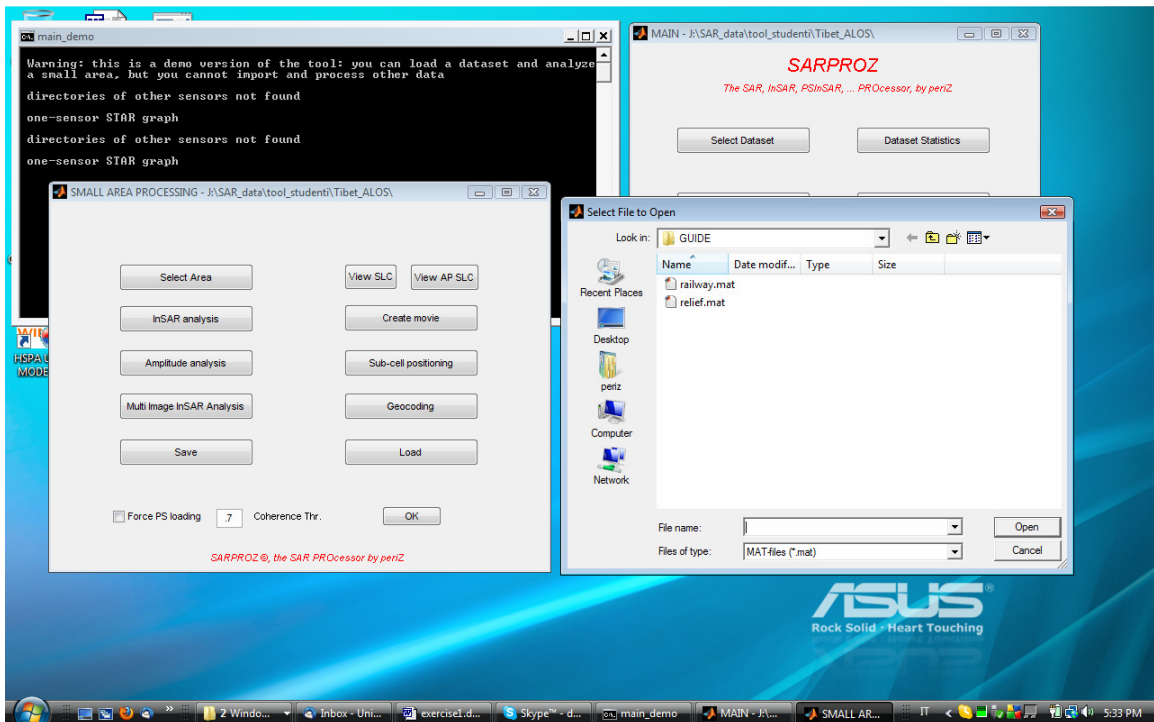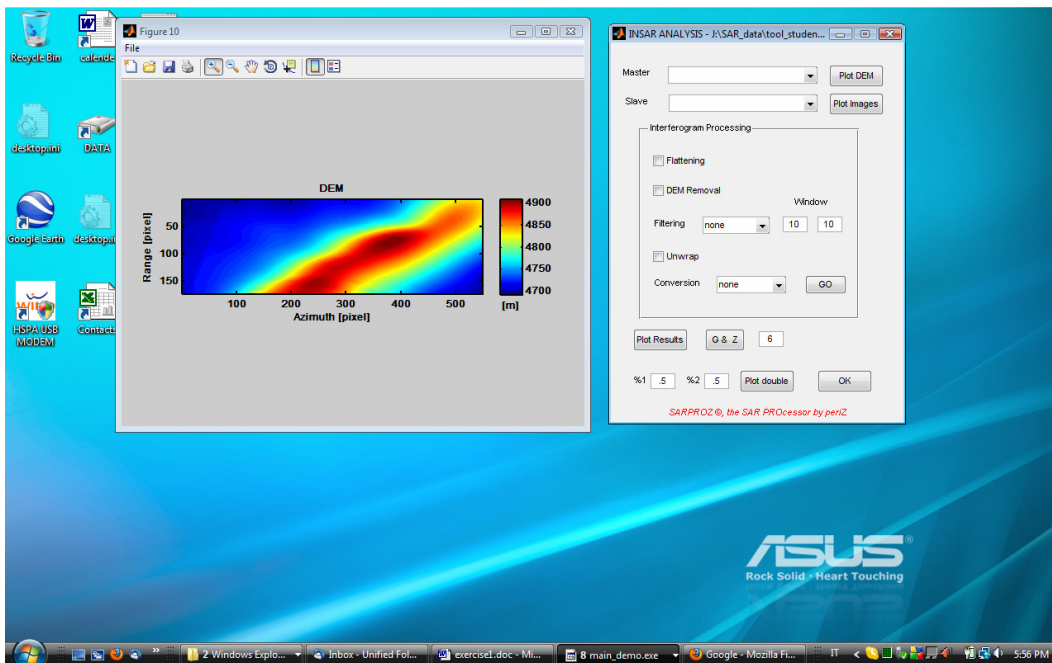
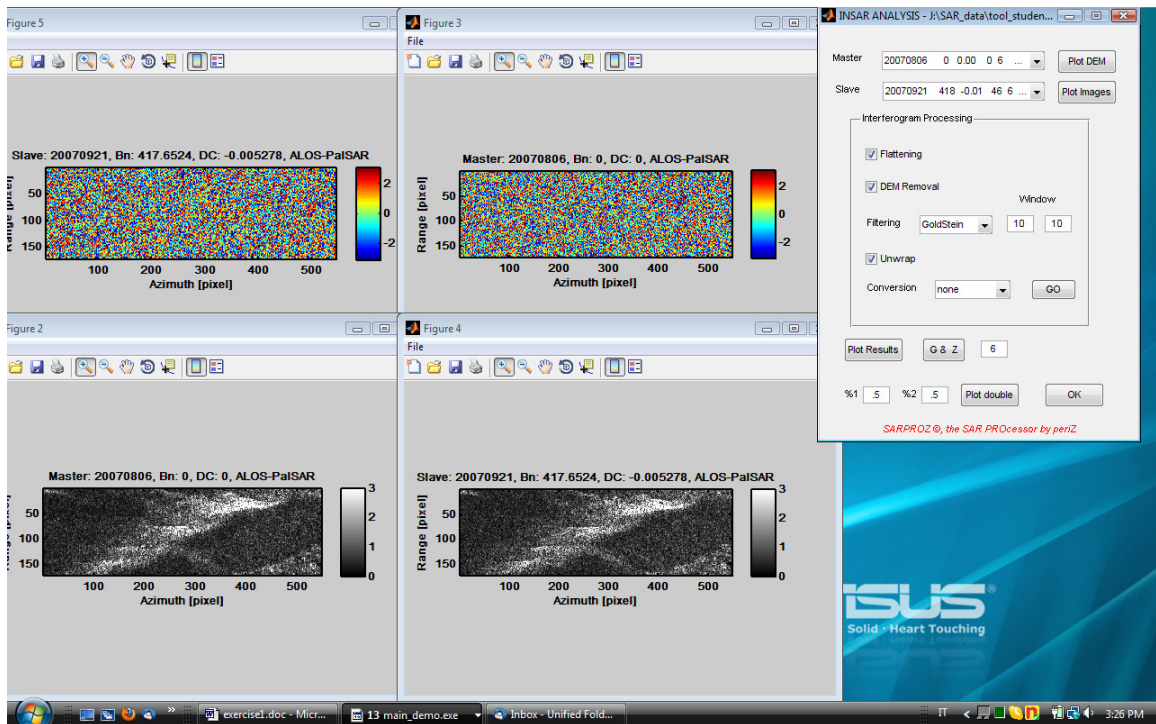7. You can now press the button "InSAR analysis" to access the related module

1.1 Operations performed through the InSAR module:

1. Plotting the External DEM corresponding to the analyzed area ("Plot DEM"):

2. Choosing a couple of images for generating an interferogram and viewing the SLC images ("Plot Images")

NOTE: for selecting the images, click on the "Master" and "Slave" popup menus.
The list of all images of the dataset will appear. For each image the following data are displayed:
Acquisition date (yyyymmdd), Normal Baseline in meters w.r.t the Master image, Doppler Centroid as a fraction of PRF, Temporal Baseline in days, a number identifying the sensor and a simulated temperature.
The parameters are shown also as titles of the plotted images.

3. Applying interferometric processing.
At this point, you can choose which interferometric operations to carry out.
Choices are:
- flattening (compensating for flat terrain)
- DEM removal
- Filtering (you can choose among BoxCar, Goldsteing, Median, moreover, you can choose the window size)
- Unwrapping
- Phase conversion (to elevation in meters or to motion in millimiters)

By pressing the button "Go", the chosen operations are processed. To view the output, click "Plot Results".
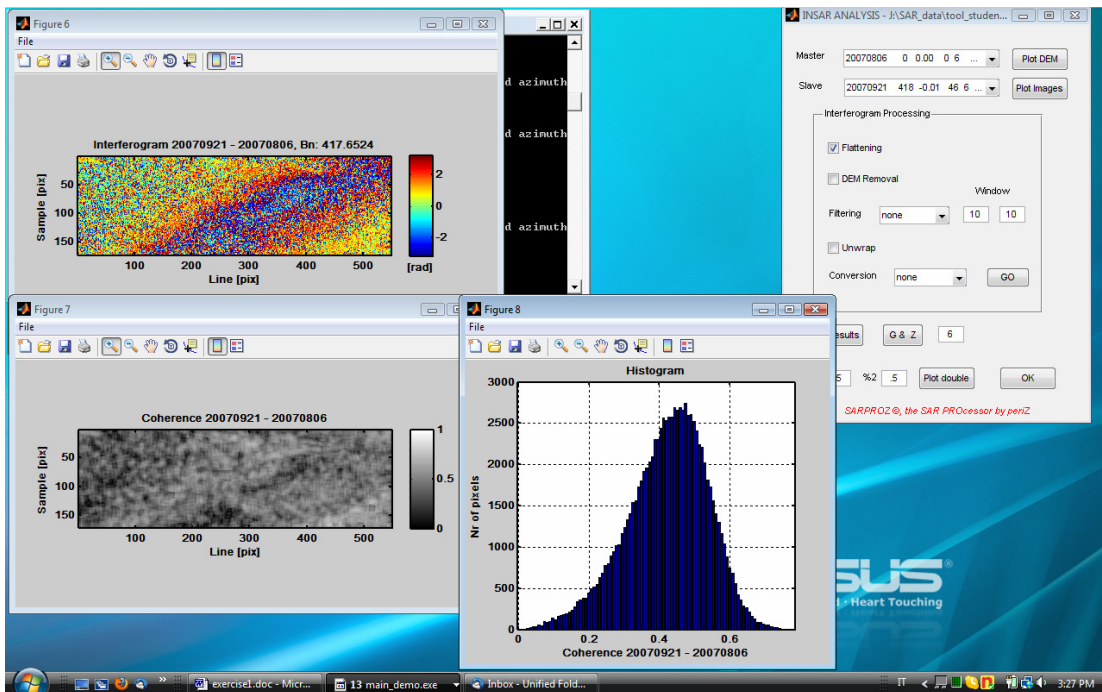
Three images are displayed:
- Interferometric phase
- Interferometric coherence
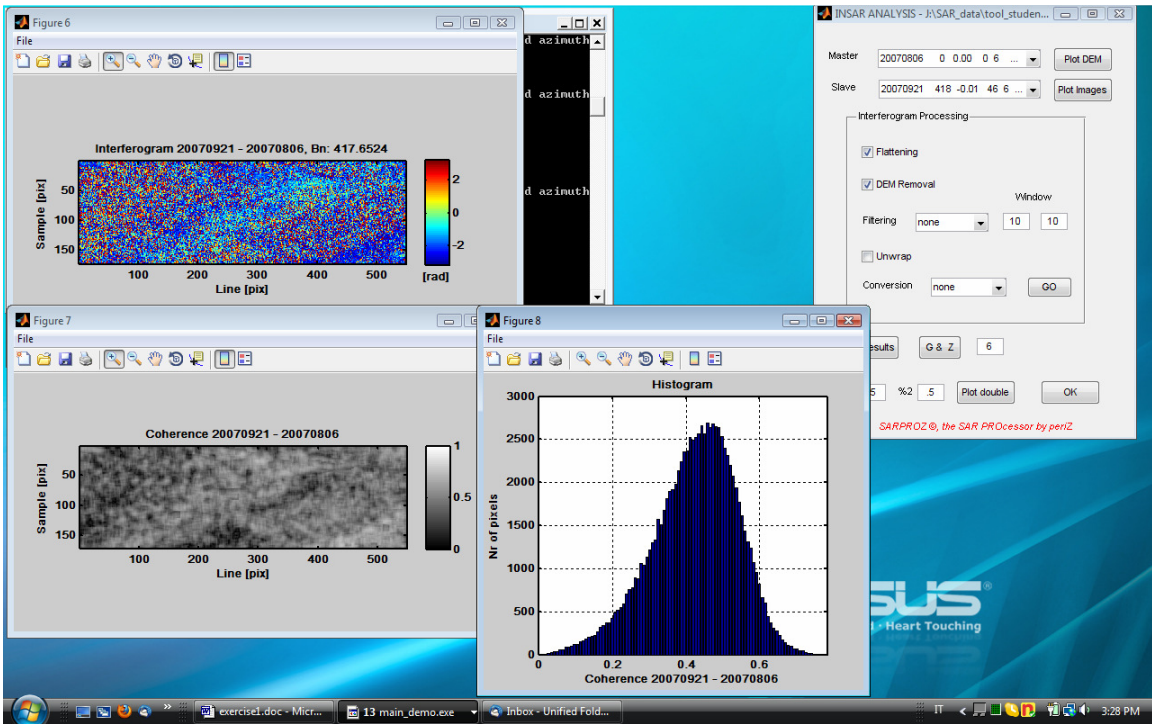- A histogram of the coherence

The images titles show the involved images pair and the relative normal baseline
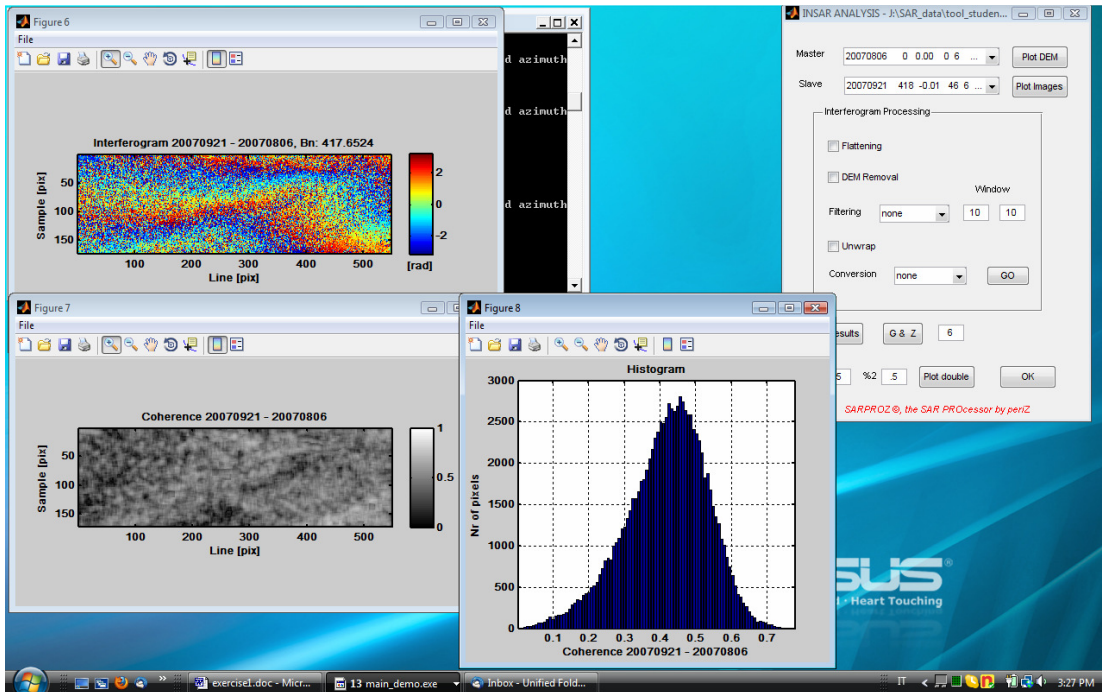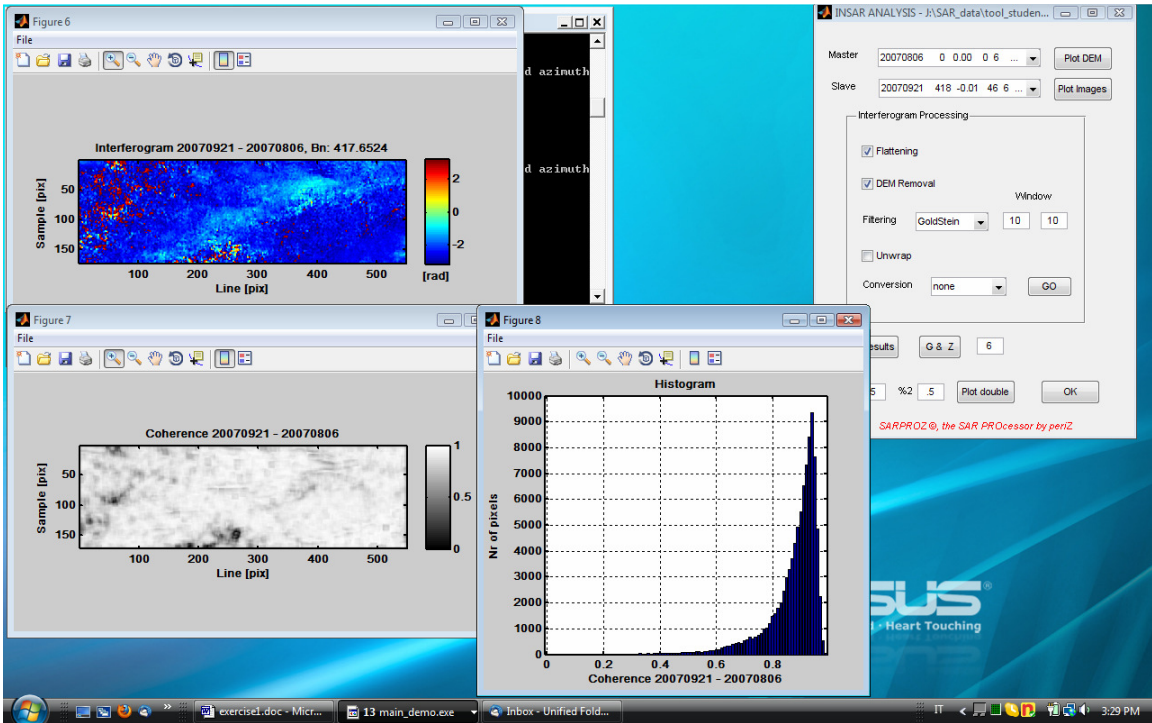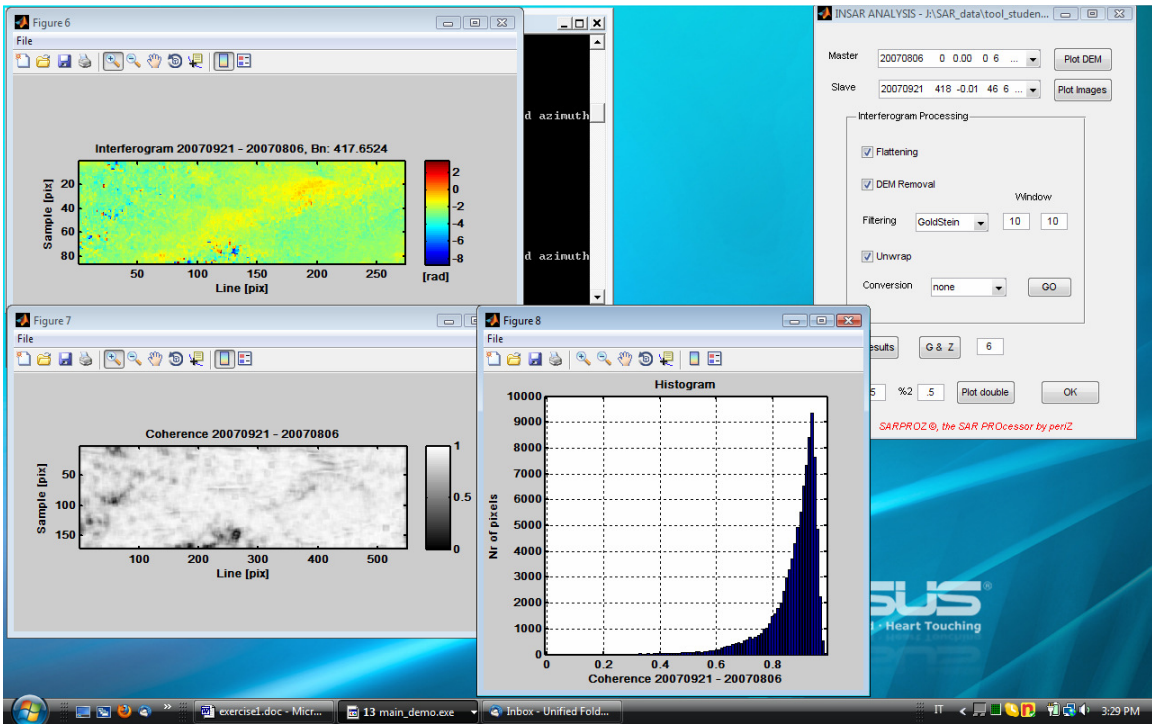

Raw Interferogram
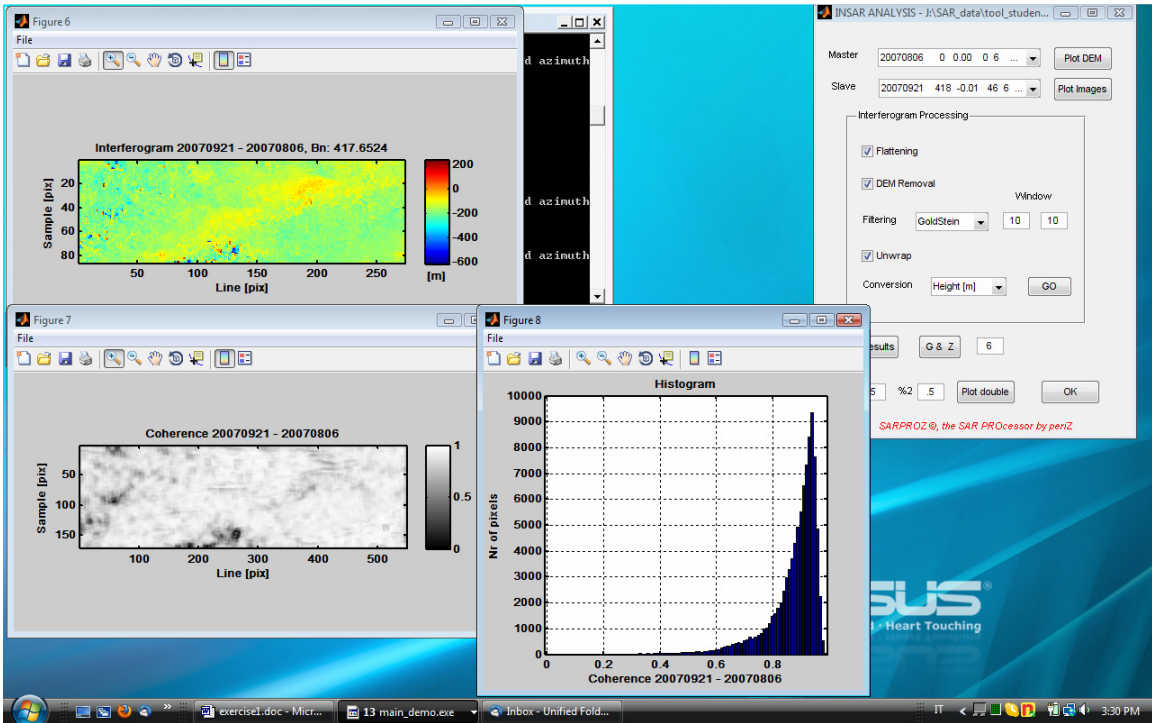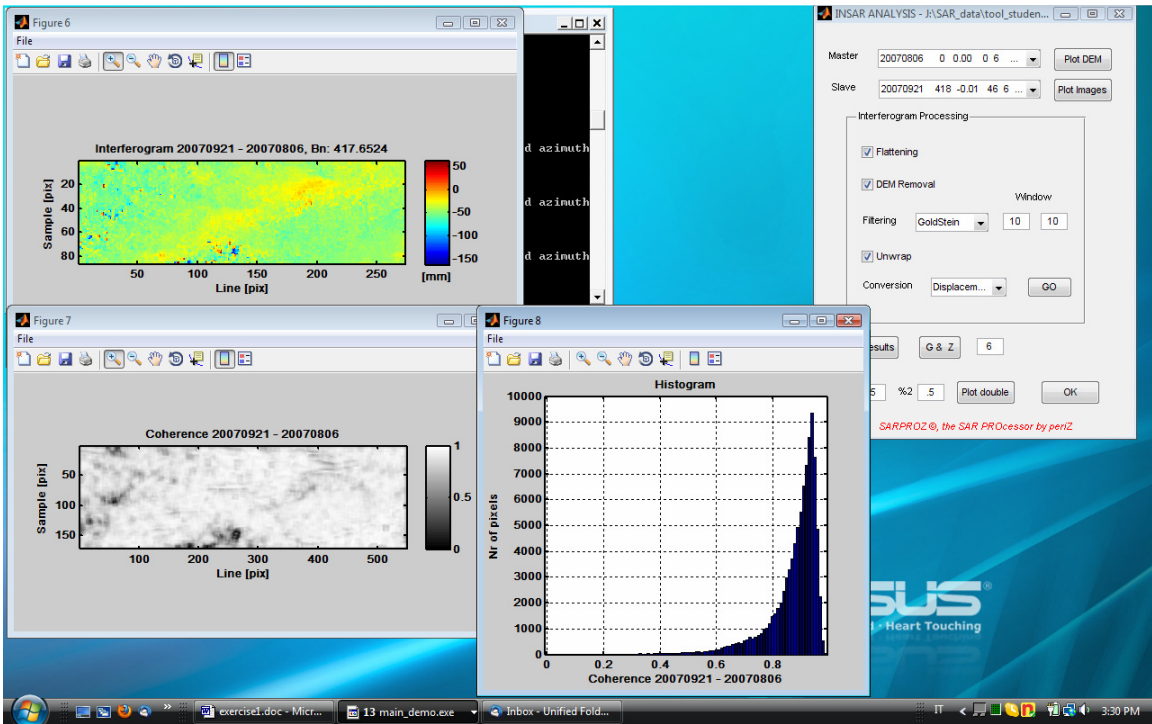

Flattened interferogram

Interferogram after DEM removal
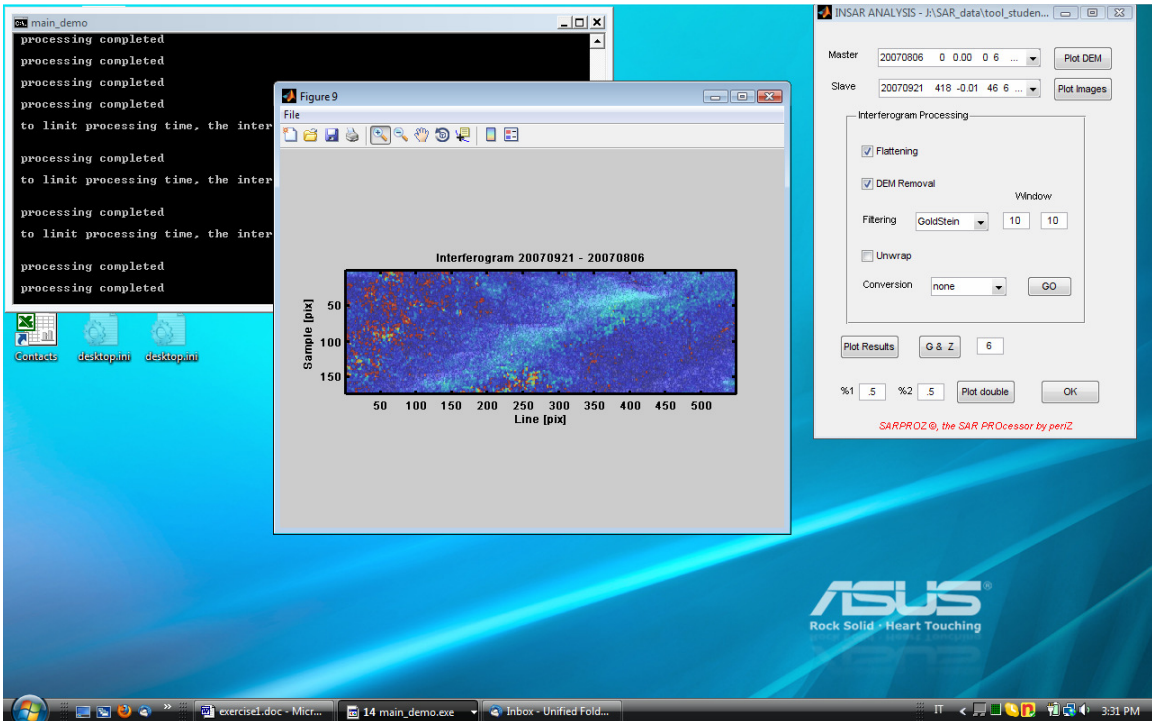

Interferogram after Goldstein filtering

Unwrapped interferogram

Unwrapped interferogram in meters

Unwrapped interferogram in millimiters

Interferogram superimposed on the image amplitude ("Plot double")

Exercises, questions and tests:

- Repeat the above mentioned steps for different pair of images
- Is there any correlation between the interferometric coherence and the parameters of the chosen pair of images?
- What happens by changing the filtering window size?
- Which are the main differences between the three available filters?
- In presence of phase residuals, is there a way to understand whether they derive from residual topography or from terrain displacement?
- Find examples of phase unwrapping errors

2.0 PSInSAR

1. Run the tool by double clicking the executable file main_demo.exe
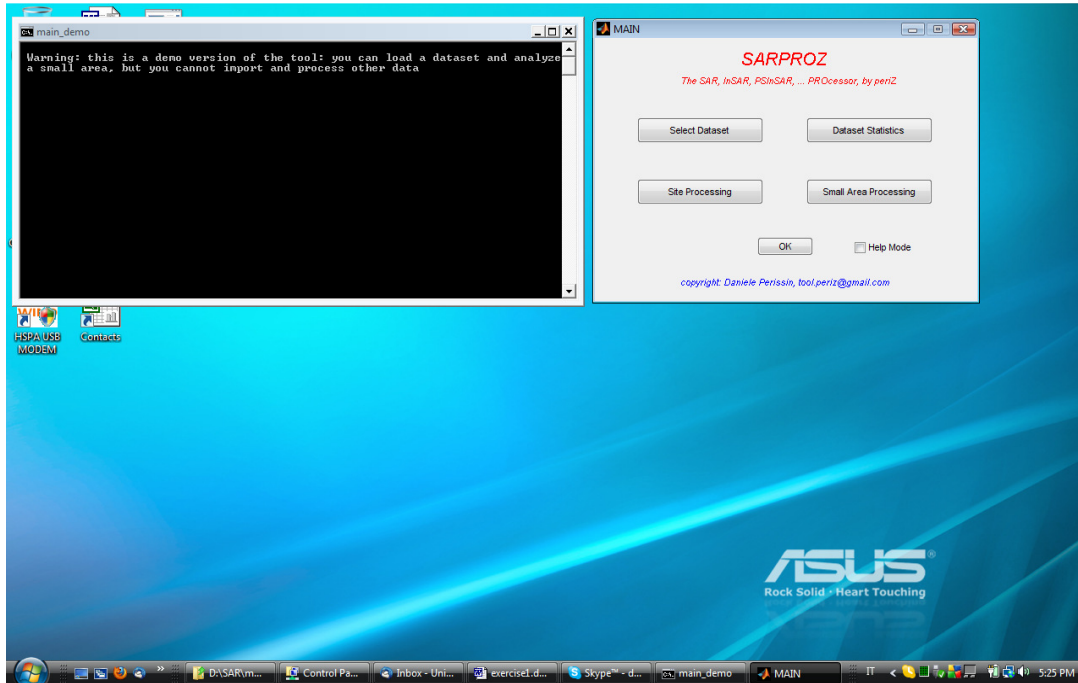
2. Select the dataset to process by clicking on "Select Dataset" and consequently "Select", then choose the directory "CUHK_TerraSAR"
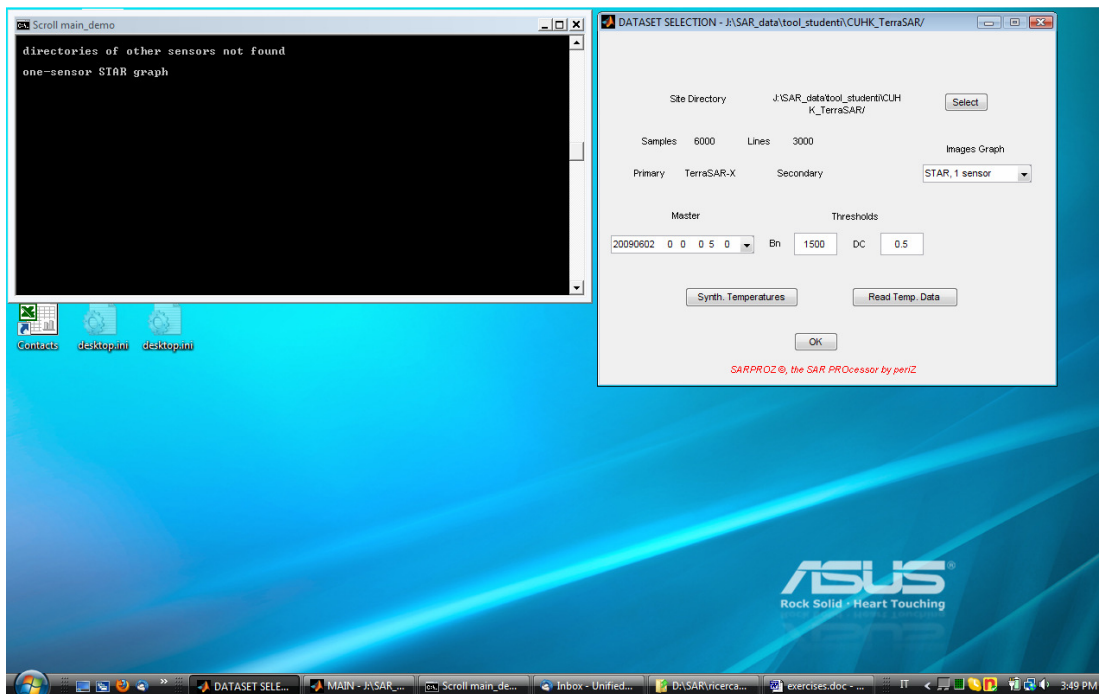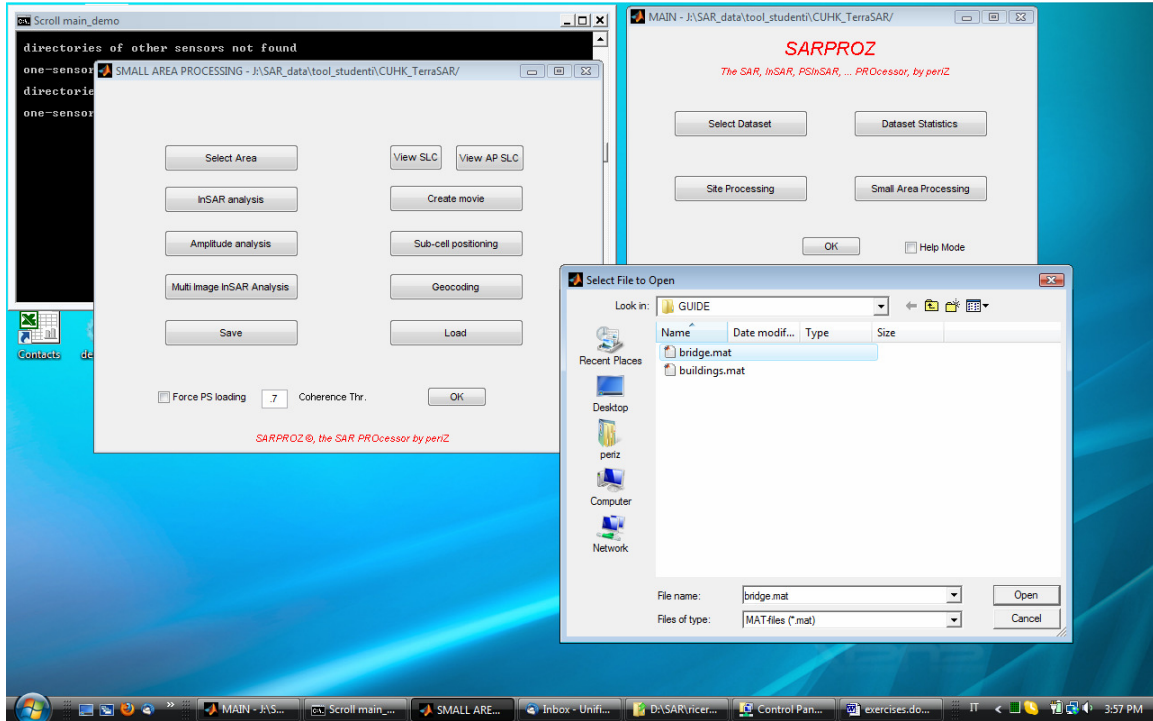
3. Open "Small Area Processing", load the saved data "bridge.mat"

4. Click on "Amplitude Analysis", from which you can choose a set of sparse points to process
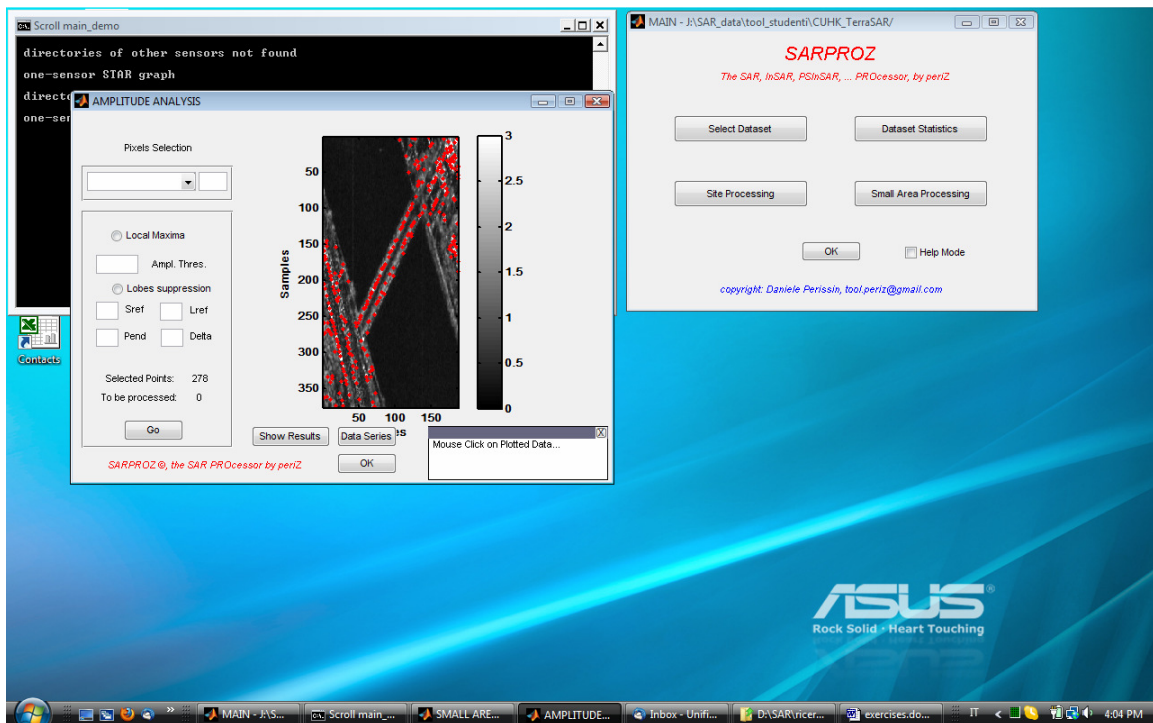
5. Open the window "Multi Image InSAR analysis"

2.1 Options in the Multi-Image InSAR module:

1. Reference point selection: choose a parameter to maximize (eg, the "Amplitude Stability Index, Mu/Sigma"). The reference point will be displayed in blue color
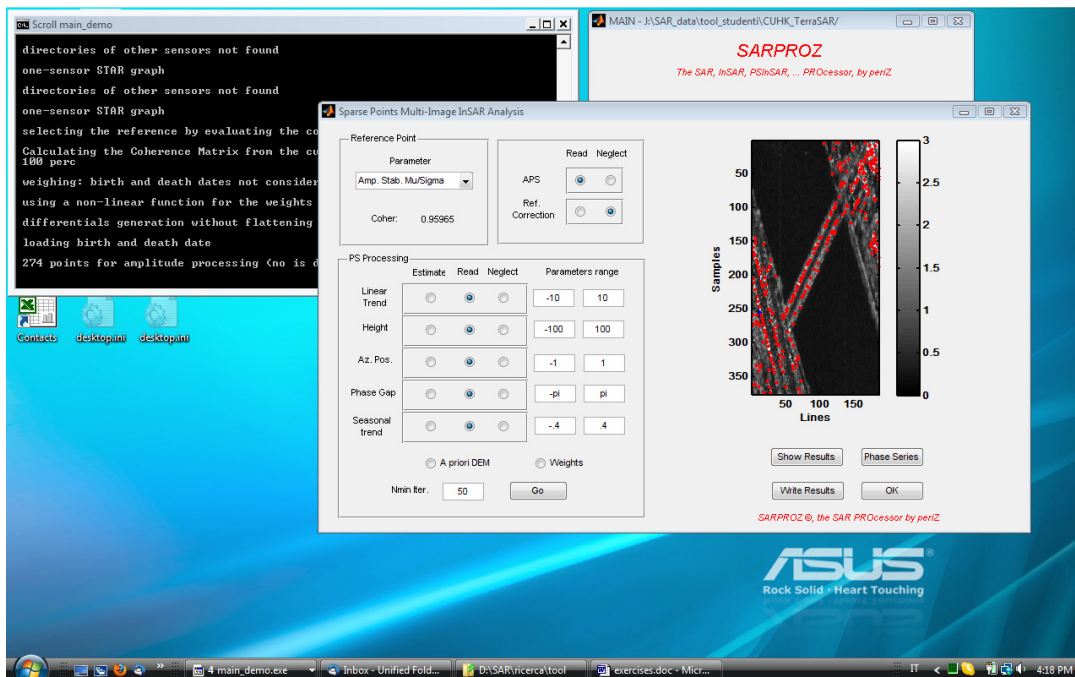
2. Choose whether to compensate for previously estimated Atmospheric Phase Screen (Read or neglect). If no, you can choose to correct for the noise of the reference point.
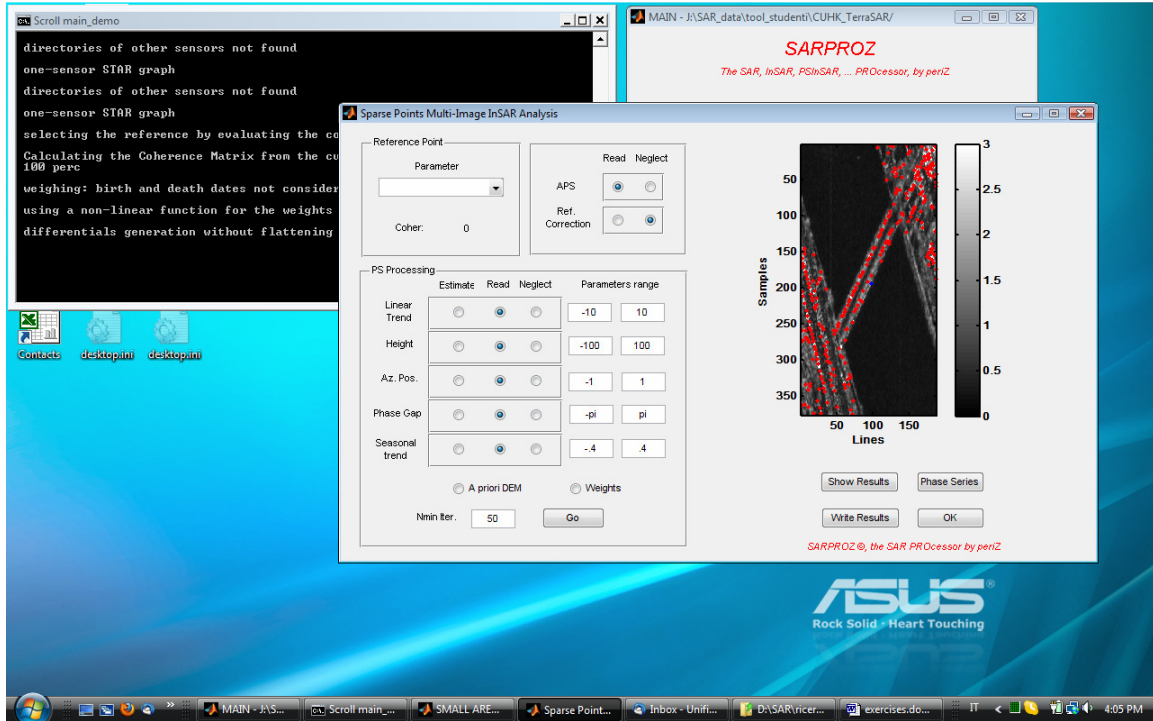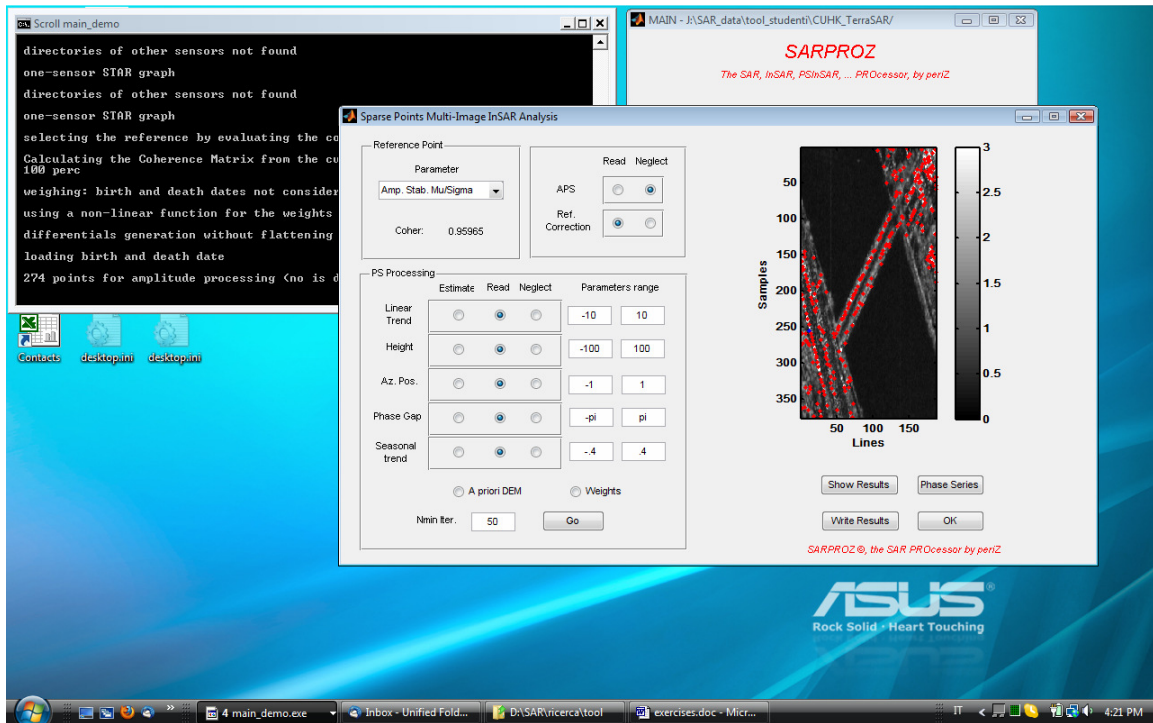

3. Choose which parameters to estimate for each selected pixel and the corresponding range of values. You can also choose to compensate for the External DEM.
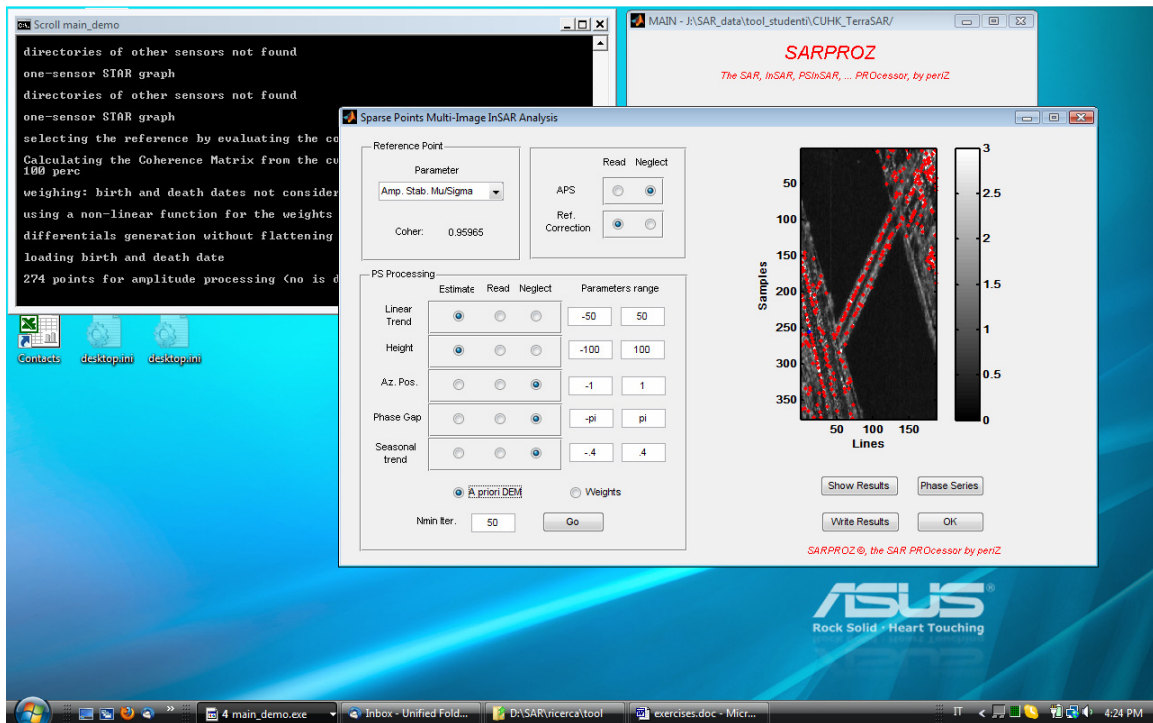
4. Through the button "Show results" you can plot the outcome: Temporal coherence for all analyzed points, its histogram and the estimated parameters
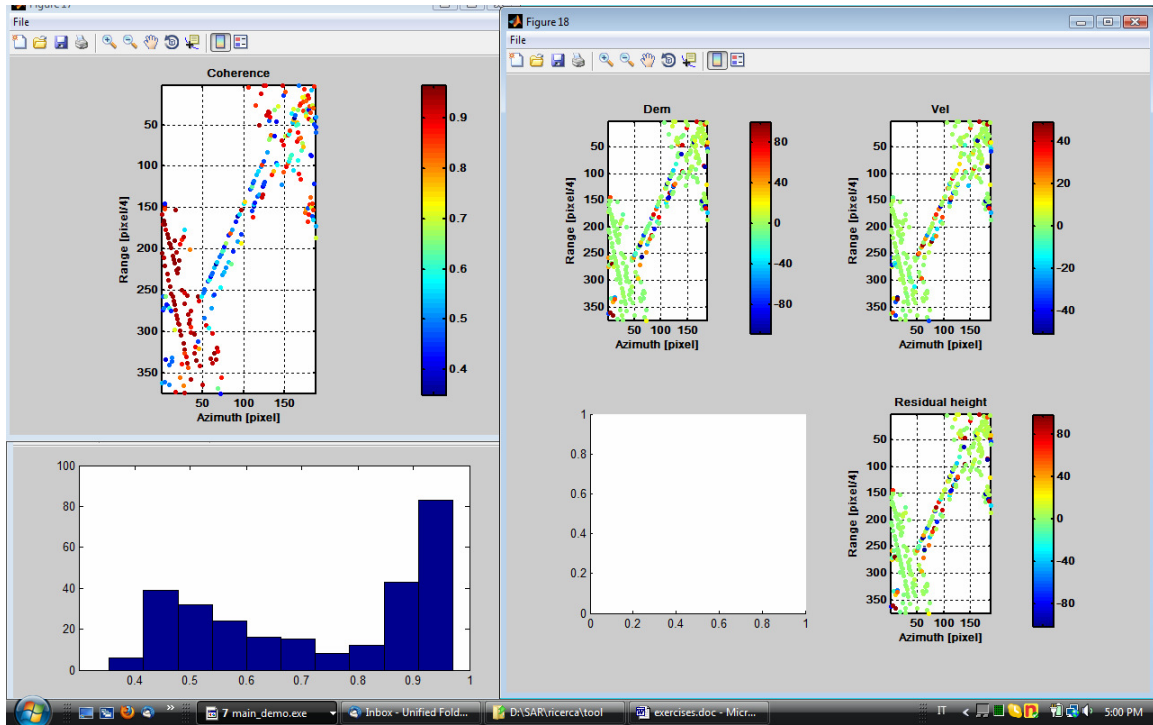
5. From the "Small Area Processing" select the button "Geocoding"

2.2 Functions of the Geocoding module:

Through the geocoding module you can visualize with a color scale a parameter previously estimated by choosing it from the list on the right

Clicking on "View lines" the satellite Line Of Sight is shown
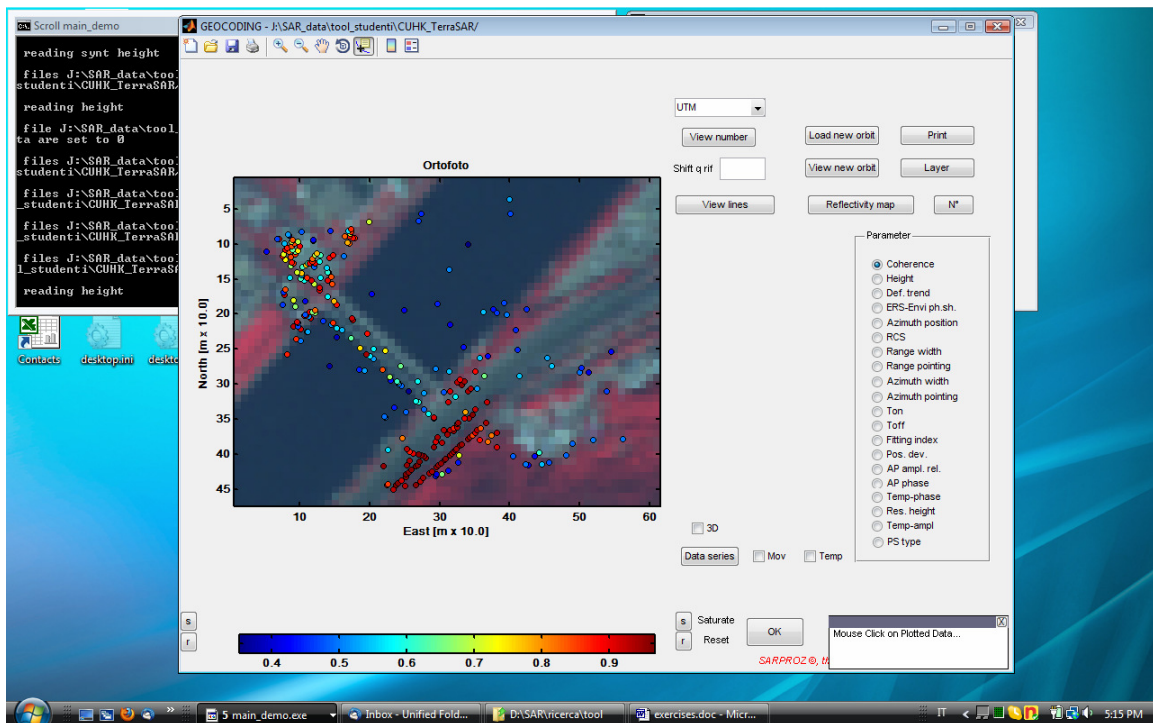
The button "View number" places a sequential number on all selected targets
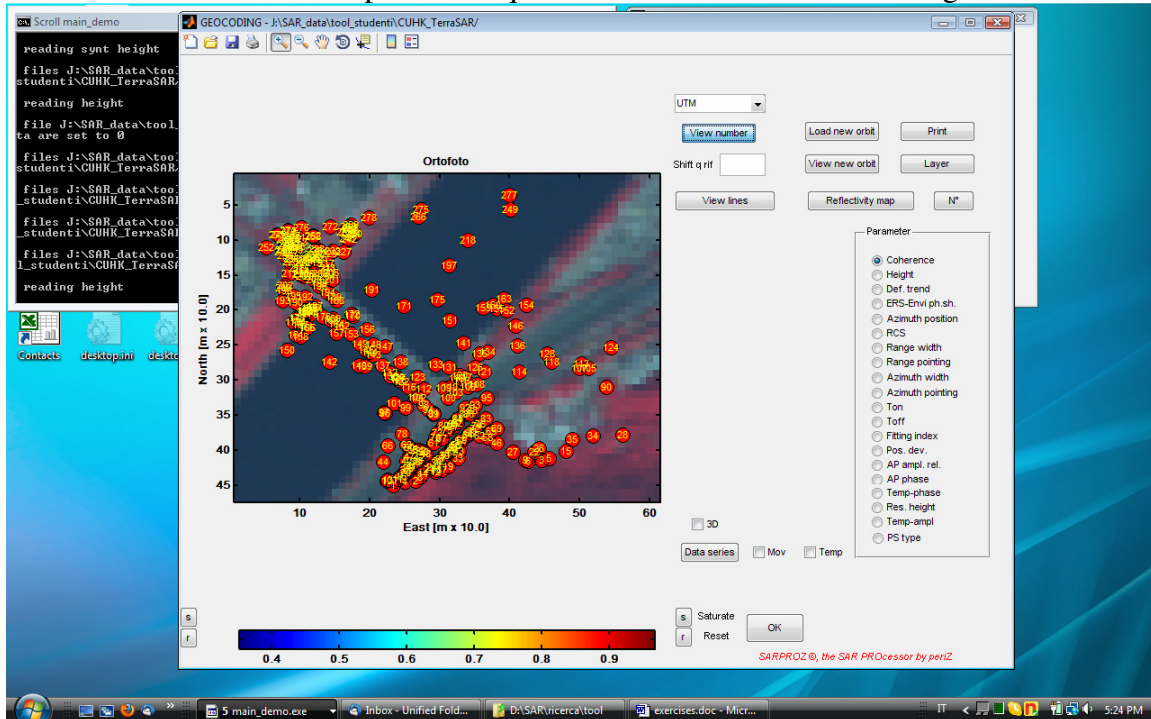
Through "Reflectivity map" a projection of the radar amplitude in the same coordinate system of the optical layer is shown. The nearby button "N°" adds the same sequential number above mentioned, to find the targets on the original SAR image
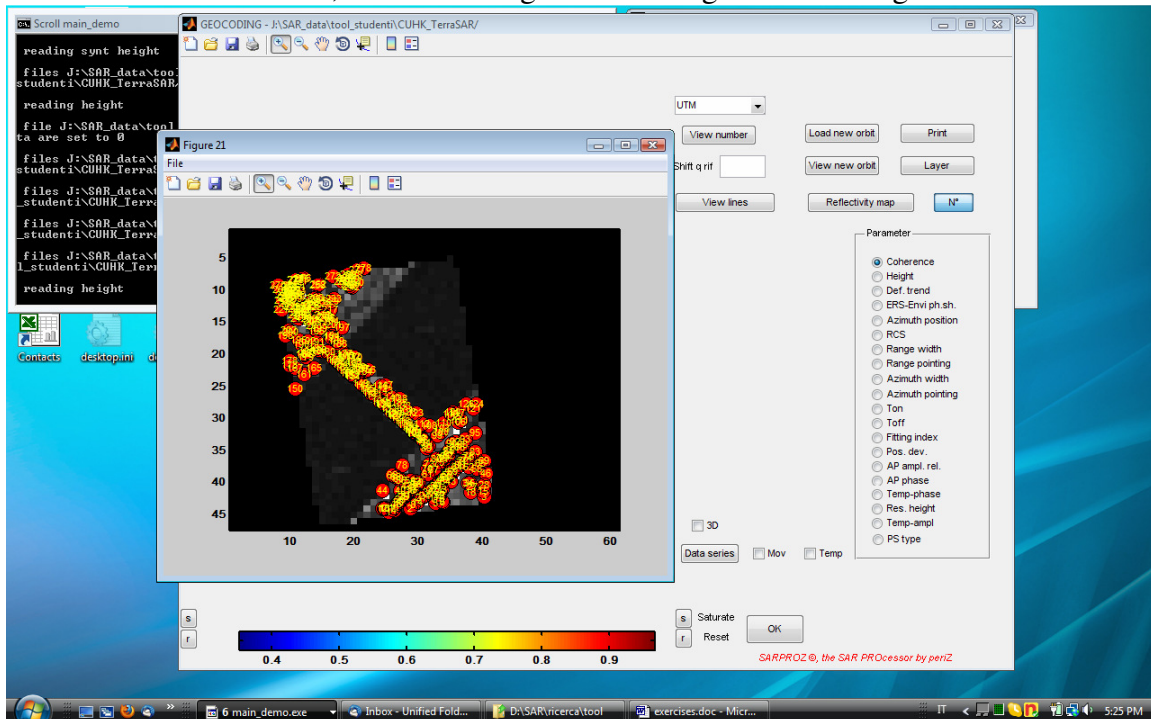
By selecting a target with the "Data Cursor" Matlab plot tool, all estimated parameters of the selected target are listed.
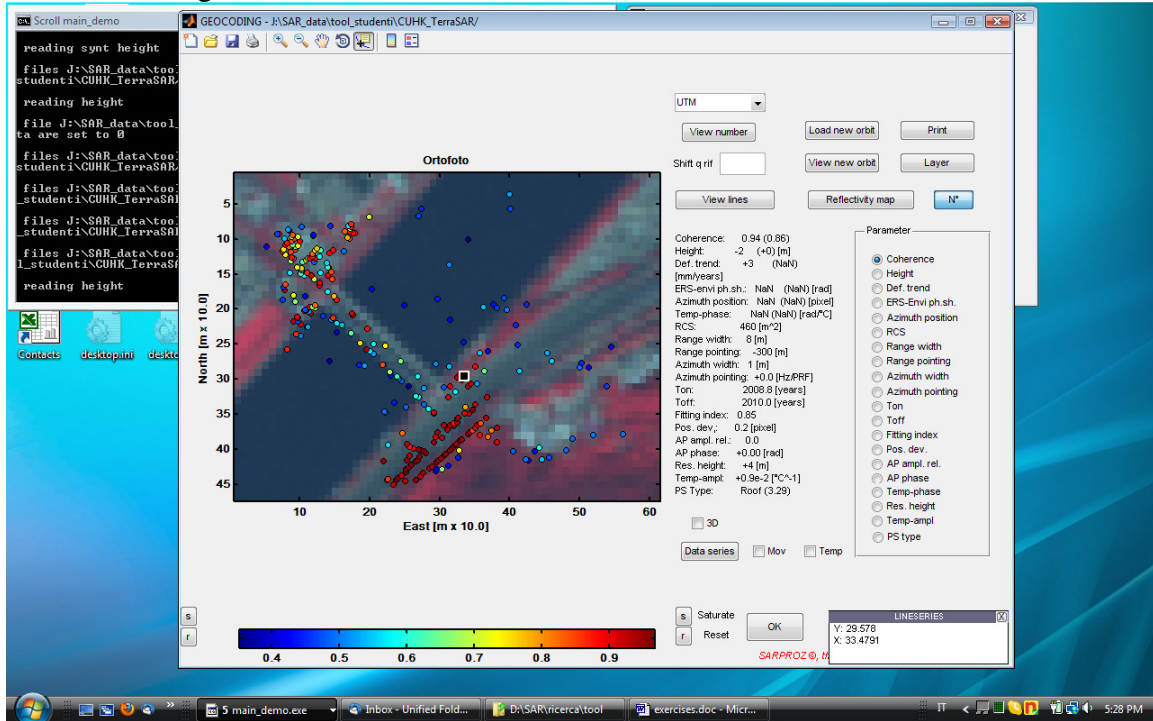
The "Data Series" button opens three figures showing amplitude and residual phase time series as functions of acquisition date, normal baseline and Doppler Centroid
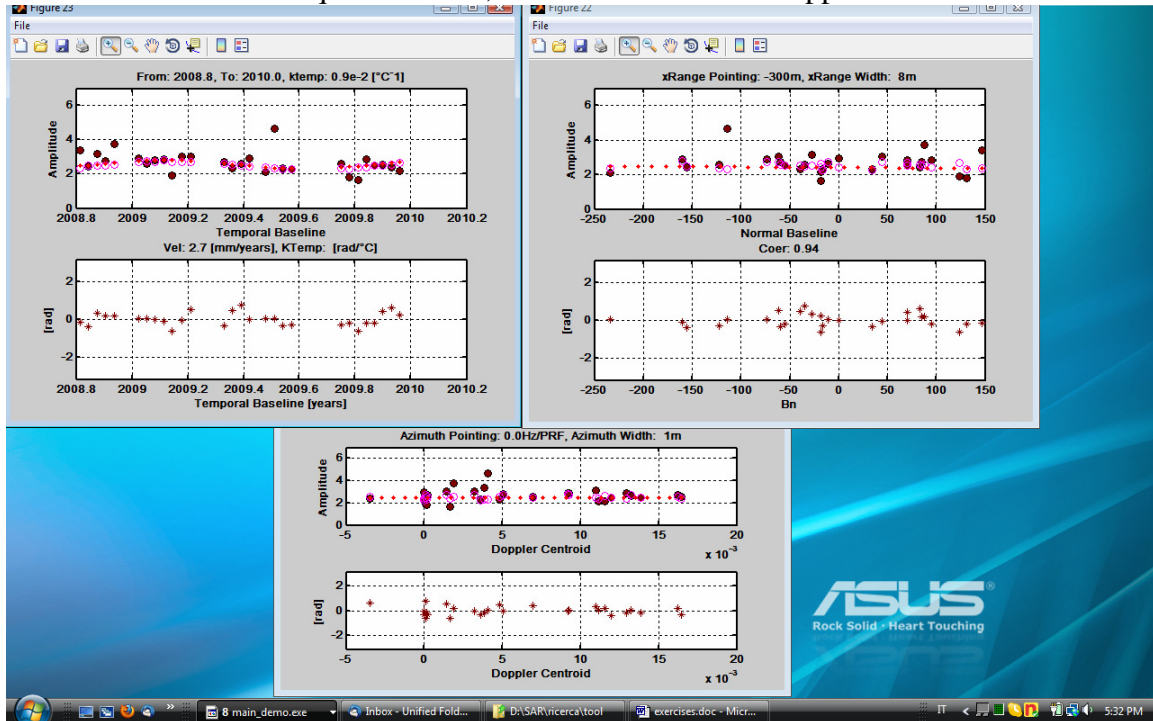
"Data Series", after checking "Mov" and "Temp" (respectively, movement and temperature) shows the phase time series as a function of time without removing the correspondent phase terms. Two replicas are also shown.
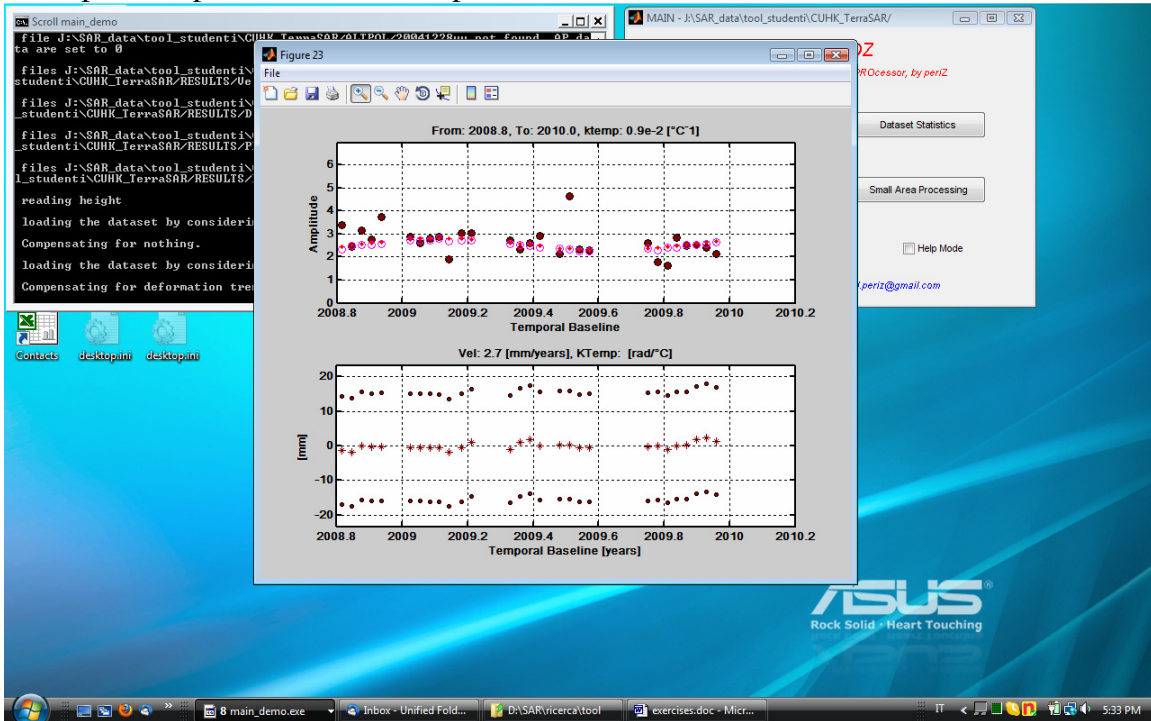
Exercises, questions and tests:

- How to identify possible errors in the parameters estimation? Is it possible to give a quantitative evaluation?
- Comment examples of phase time series of good and bad targets.
- Which could be the reasons for errors in the parameters estimation?
- How a bad estimation of the height of a target impact on its geolocation?
- Repeat the above steps choosing different options in the "Multi image InSAR analysis".
- What happens by changing the reference point?
- Repeat the estimation including a seasonal trend in the deformation time series.
- Which could be the physical phenomena of a seasonal deformation?
- Can the time sampling of the radar acquisitions impact on the seasonal trend estimation?
- What would happen in case of other Non-Linear deformation trends?
- How to identify possible Non-Linear deformation trends?

3.0 More complex Multi-Image InSAR processing (1)

1. Run the tool by double clicking the executable file main_demo.exe
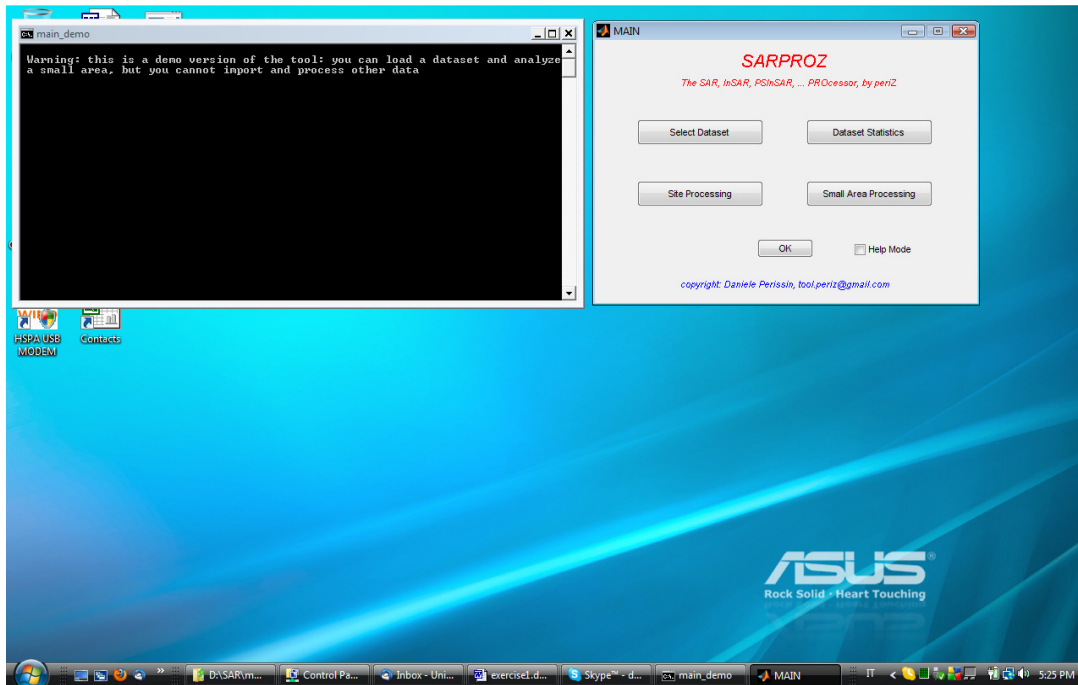
2. Select the dataset to process by clicking on "Select Dataset" and consequently "Select", then choose the directory "CUHK_TerraSAR"
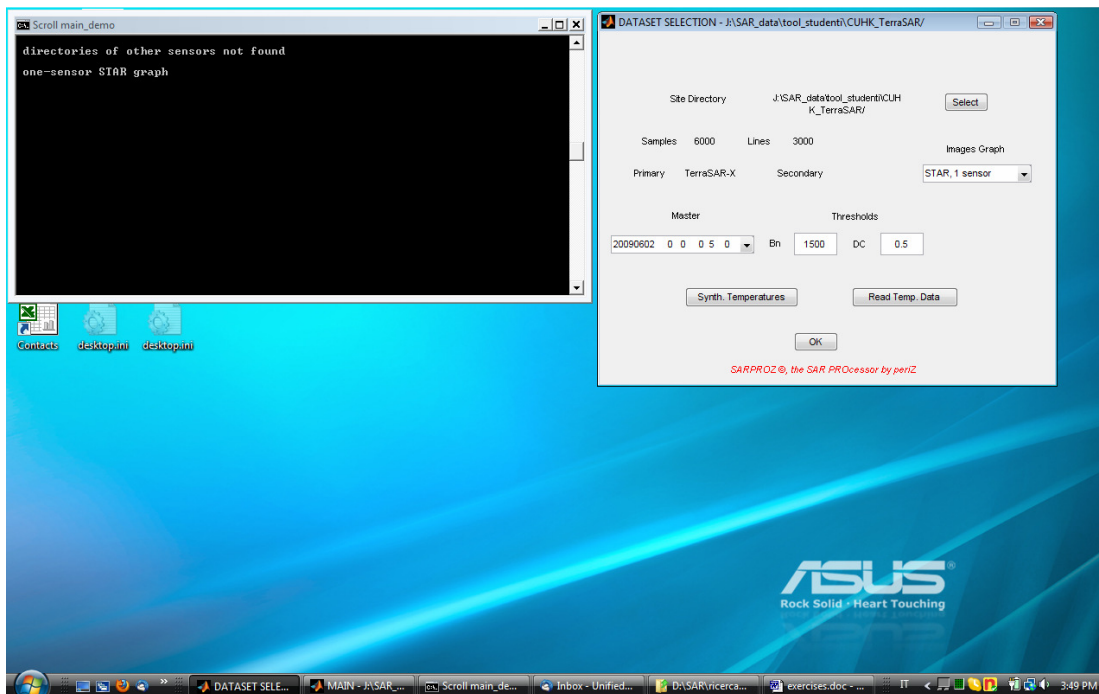
3. From the window "Dataset Selection" you can choose among different images graphs:
4.
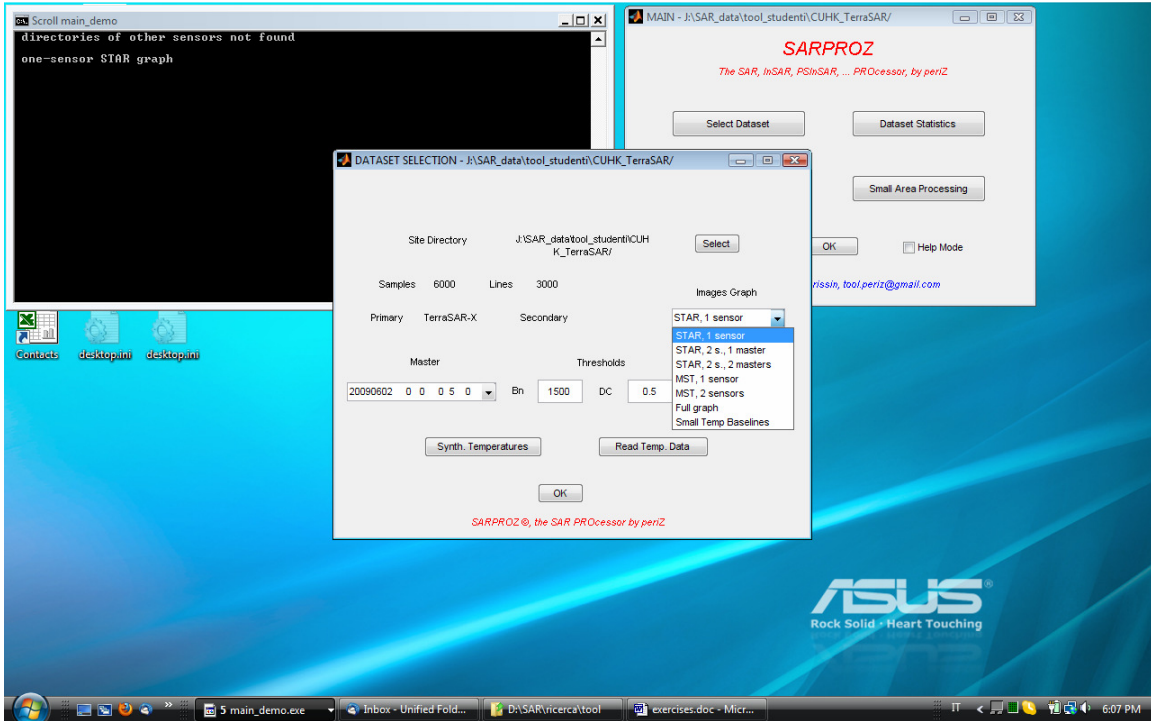
5. By clicking "Dataset Statistics", you can visualize the chose images graph:
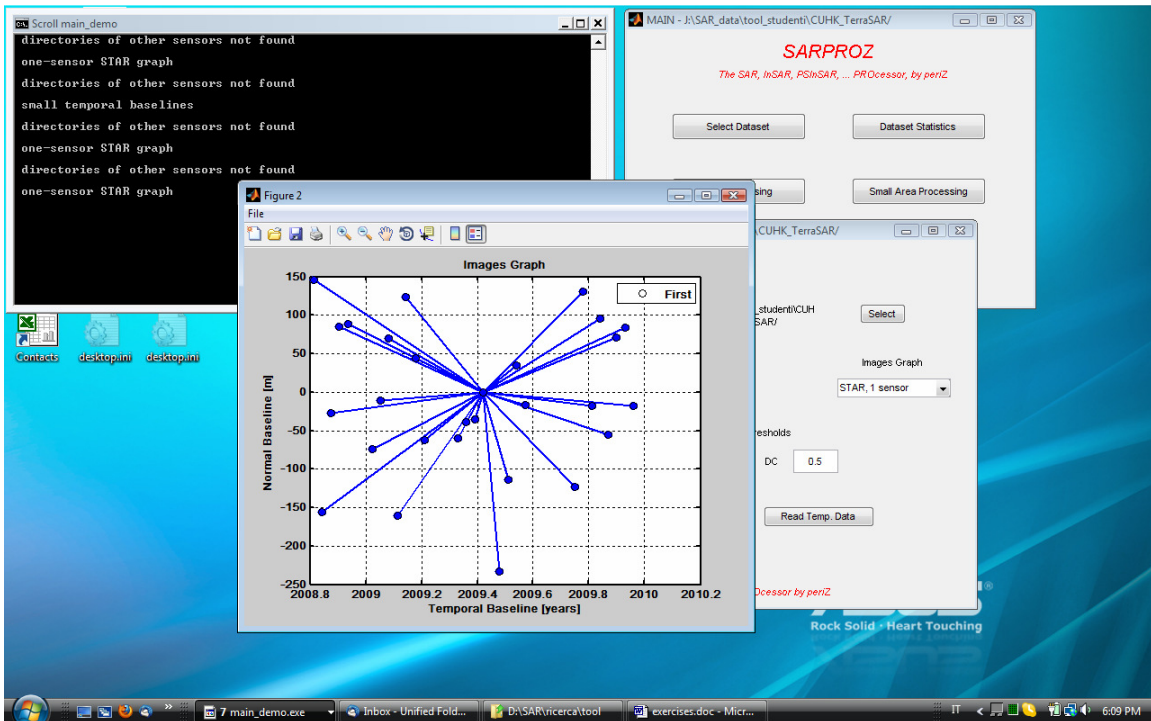
STAR (single master configuration)
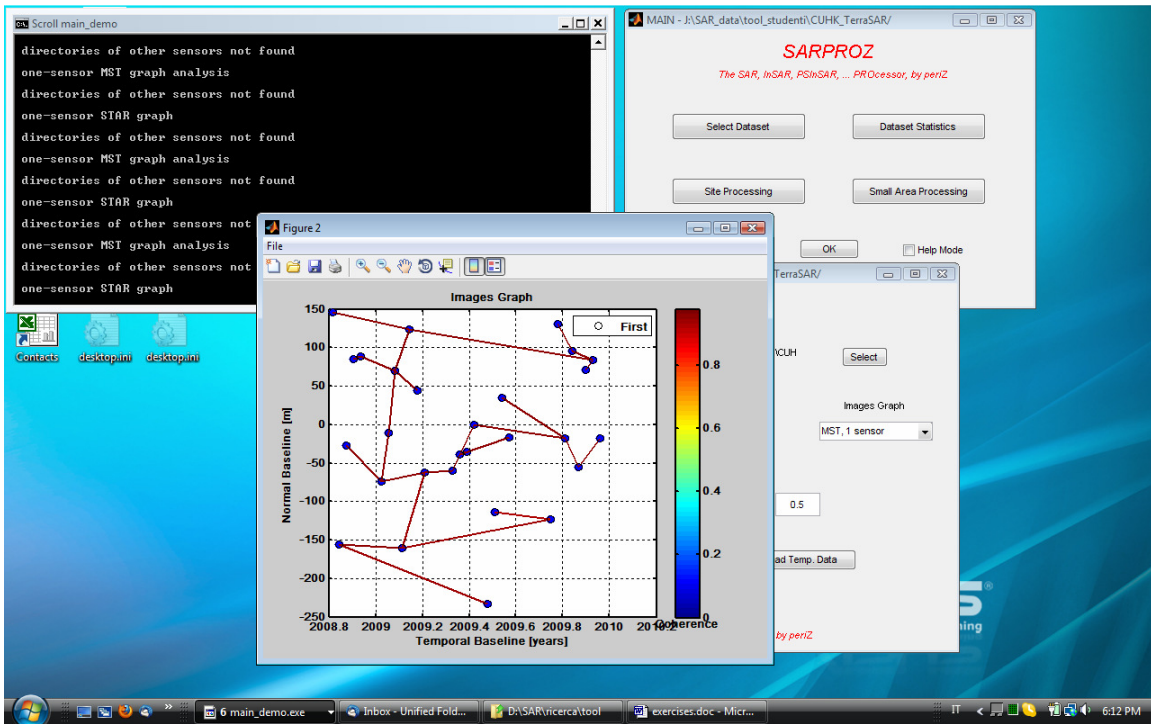
MST (Minimum Spanning Tree, obtained by maximizing the coherence of the links)
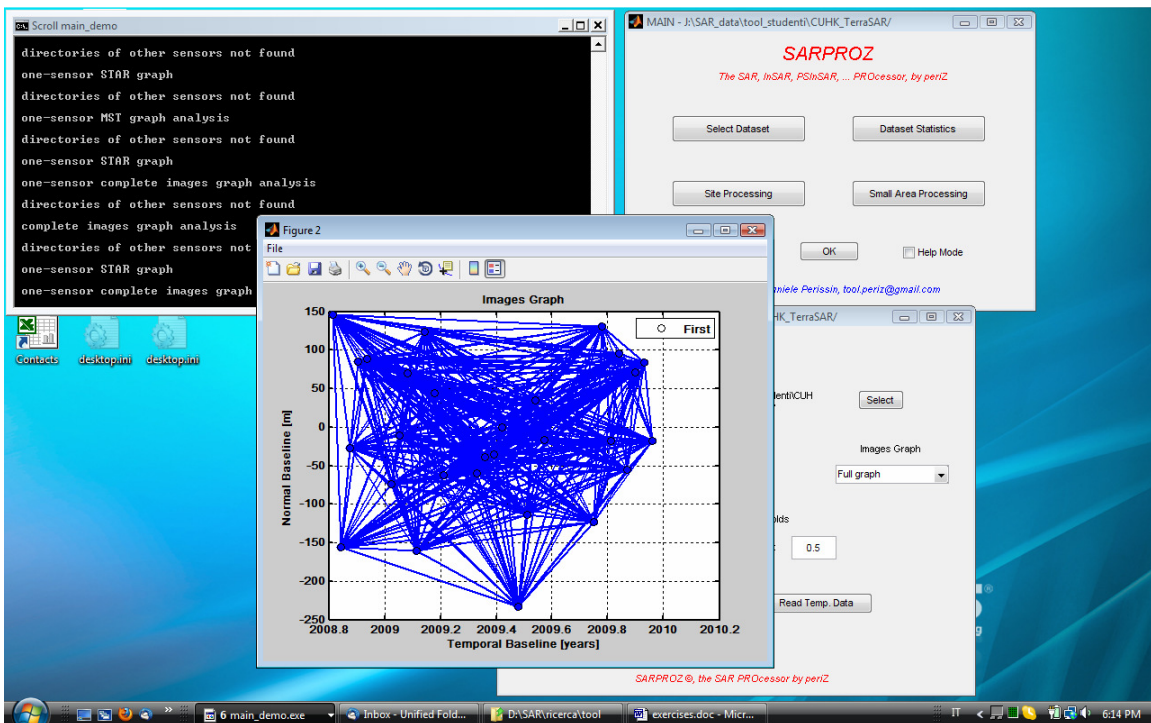
Full Graph (all possible images pairs)
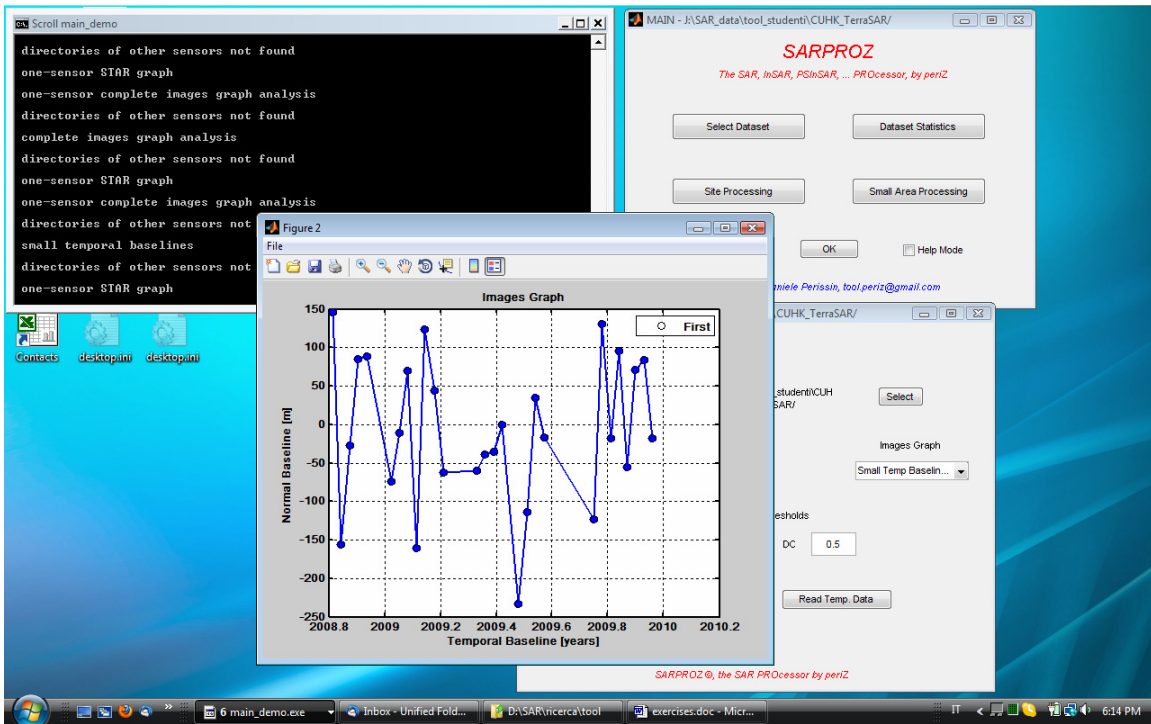
Small Temp Baselines (only consecutive images are linked)

Exercises, questions and tests:

- Repeat the PSInSAR analysis keeping all standard options unchanged BUT the images graph.
- Which are the main differences by choosing a different images graph?
- Which are pros and cons of all available images graphs?
- Can an images graph be more suitable than an other depending on the given dataset?

# 4.0 More complex Multi-Image InSAR processing (2)

1. Run the tool by double clicking the executable file main_demo.exe
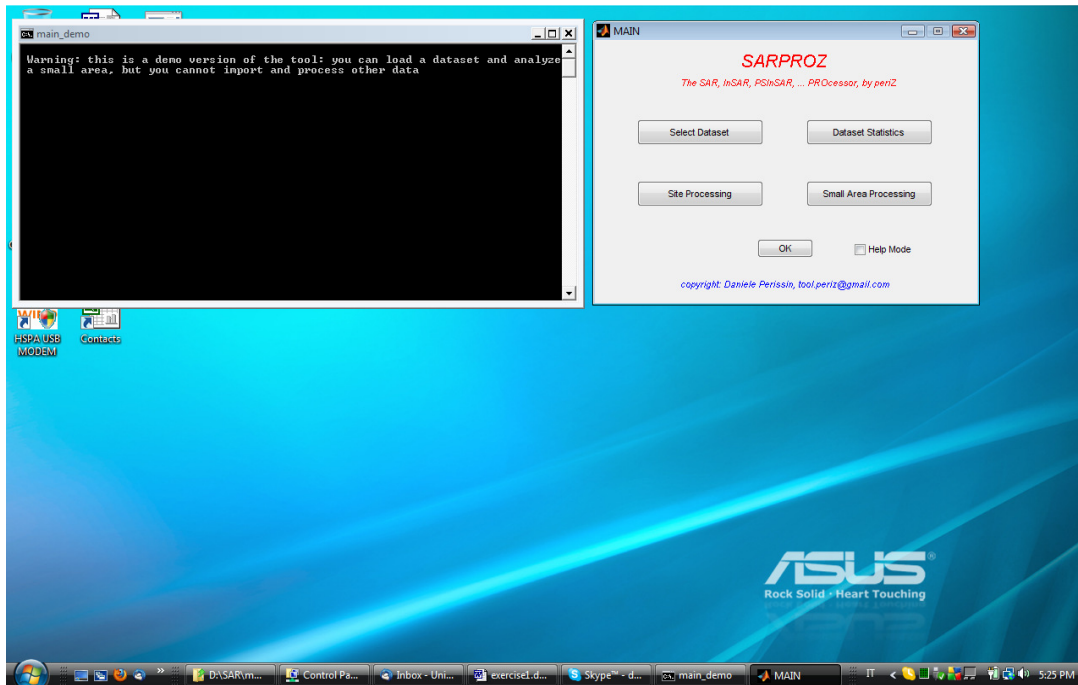

2. Select the dataset to process by clicking on "Select Dataset" and consequently "Select", then choose the directory "CUHK_TerraSAR"
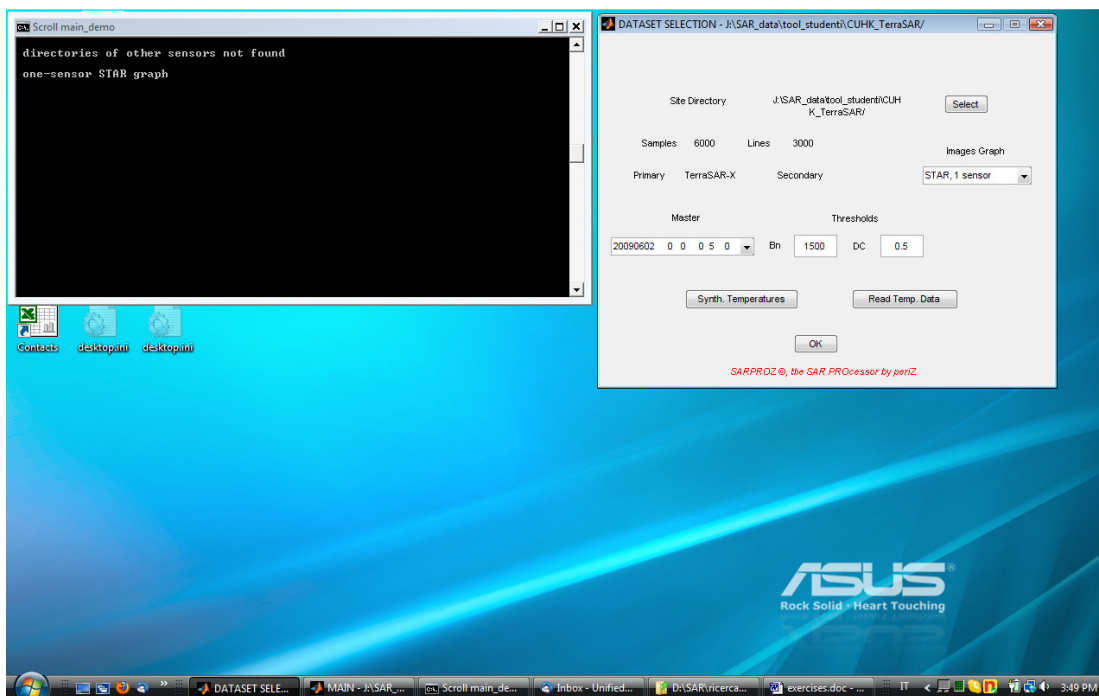
3. Choose "Small area processing", load a dataset as in the previous chapters, select a set of points to process and go to the "Multi Image InSAR Processing" module.
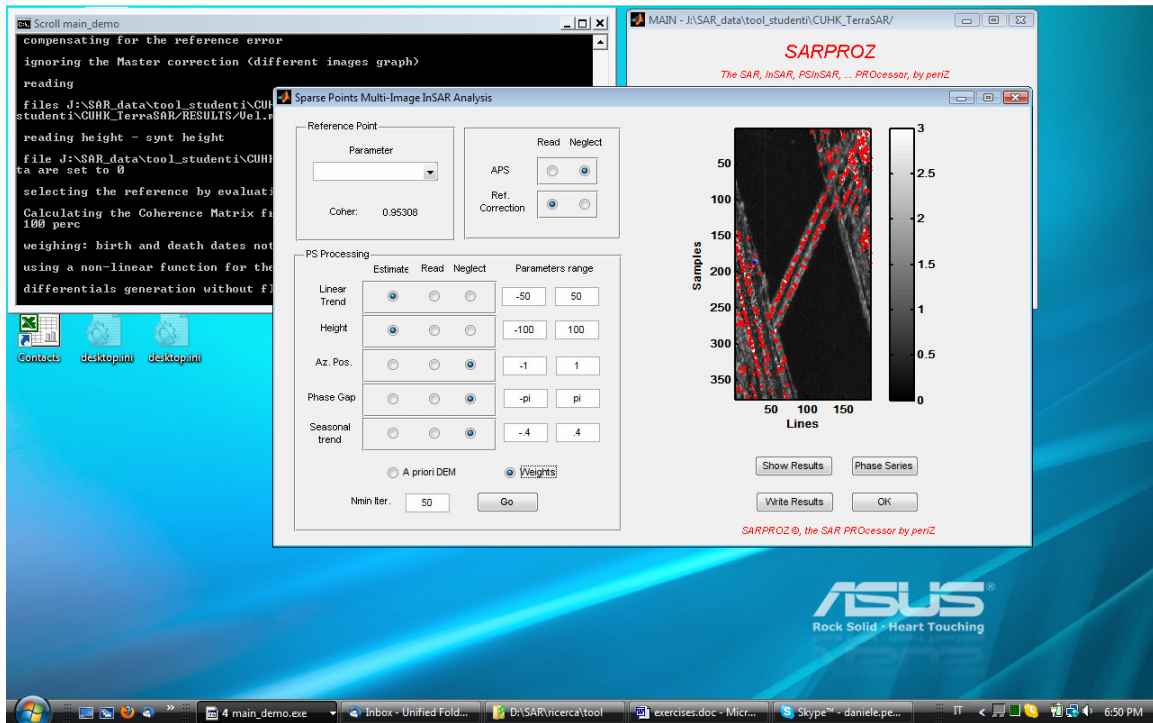
4. Among the possible choices, select the flag "Weights". Carry out the parameters estimation as in the precious chapters.

Exercises, questions and tests:

- Repeat the PSInSAR analysis previously carried out using the option "Weights".
- Comments the different results highlighting the outcome of the utilization of "Weights" for the different images graphs.

5.0 Amplitude time series analysis

1. Run the usual steps, select a dataset, open the "Small area processing" and load an example of a small area. Select a set of sparse points through the "Amplitude analysis module". After that, press "Go" and wait till all points will be processed.
   At the end, the following window will open:

Here the amplitude of all images for a selected target is shown as function of time, normal baseline and Doppler Centroid. By clicking on "Next" you can review all analyzed points.

2. By processing PSInSAR in the classic way, without the use of "Weights", eventual temporary PSs will be analyzed considering their life time.
   Carry out the steps as described in the previous chapters and then geocode the results.

3. Click on the "Geocoding" module, select the parameter "Ton" (starting time) on the right, choose a target with starting time different from the beginning, plot its data series. Phase data will be shown only for during its life time.