Exercise 1: Change Detection of Recent Flood in Texas

Sarproz processing tutorial series

By Yuxiao QIN

Downloading Sample Data

- Sample Data, Texas Houston, 2017 August Flood:
  - ~~`ftp://johndoe:psinsar12138@128.46.174.159/data/TX_FLOOD/`~~ SEE BELOW
    - **To download, manually copy & paste this URL into Google Chrome's address bar.**
  - Two data taken separately on 2017-Aug-05 and 2017-Aug-29 are included in the sample data.
  - Reference: https://www.wikiwand.com/en/Hurricane_Harvey

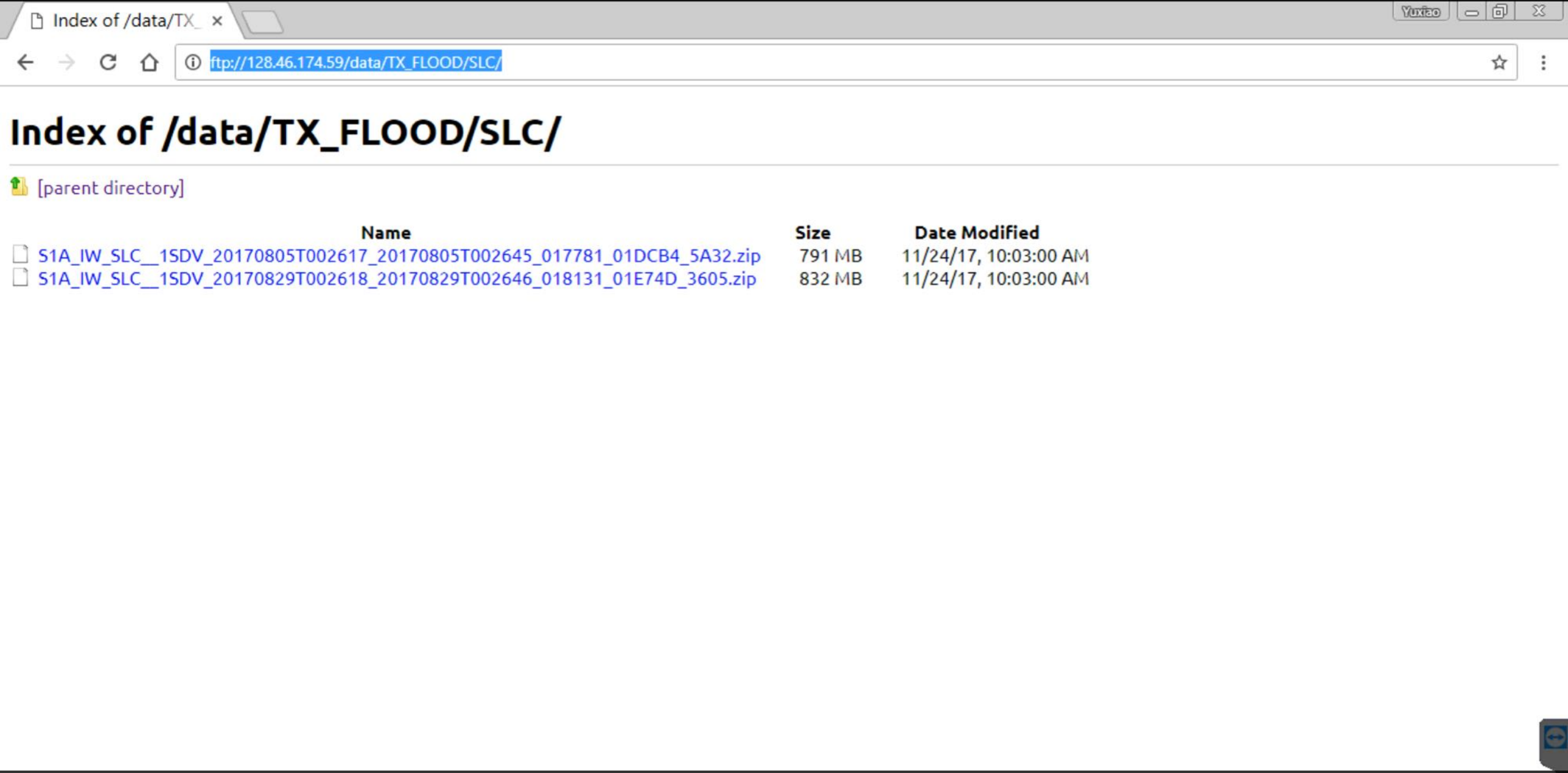
- Sample Data, Napa, California, 2014 August Earthquake:
  - ~~`ftp://johndoe:psinsar12138@128.46.174.159/data/NAPA_EQ`~~ SEE BELOW
  - Two data taken separately on 2014-Aug-07 and 2014-Aug-31 are included in the sample data.
  - Reference: http://www.wikiwand.com/en/2014_South_Napa_earthquake

!! the links above are no longer working

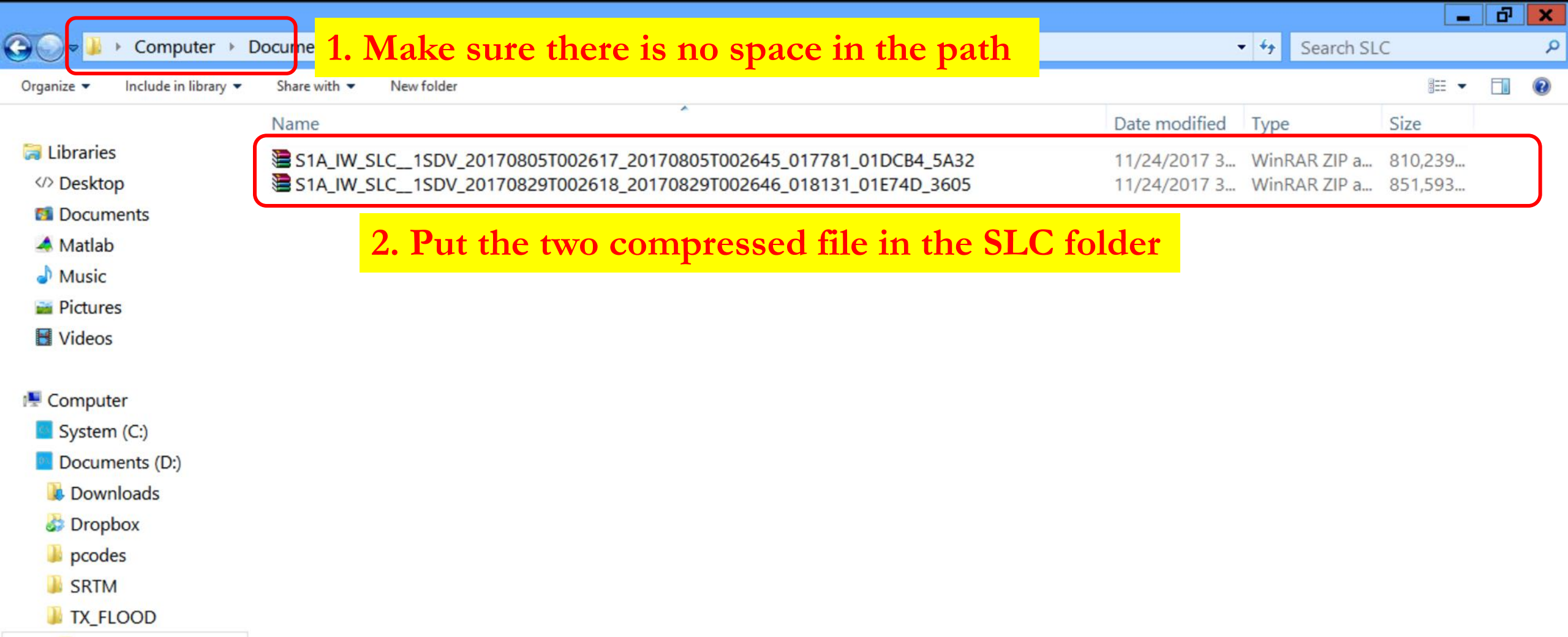
please find the data hereafter:

TEXAS FLOOD: https://my.pcloud.com/publink/show?code=XZtlbE7ZvXKViLSdGrY6RlgY55UQ9uNXFRpk

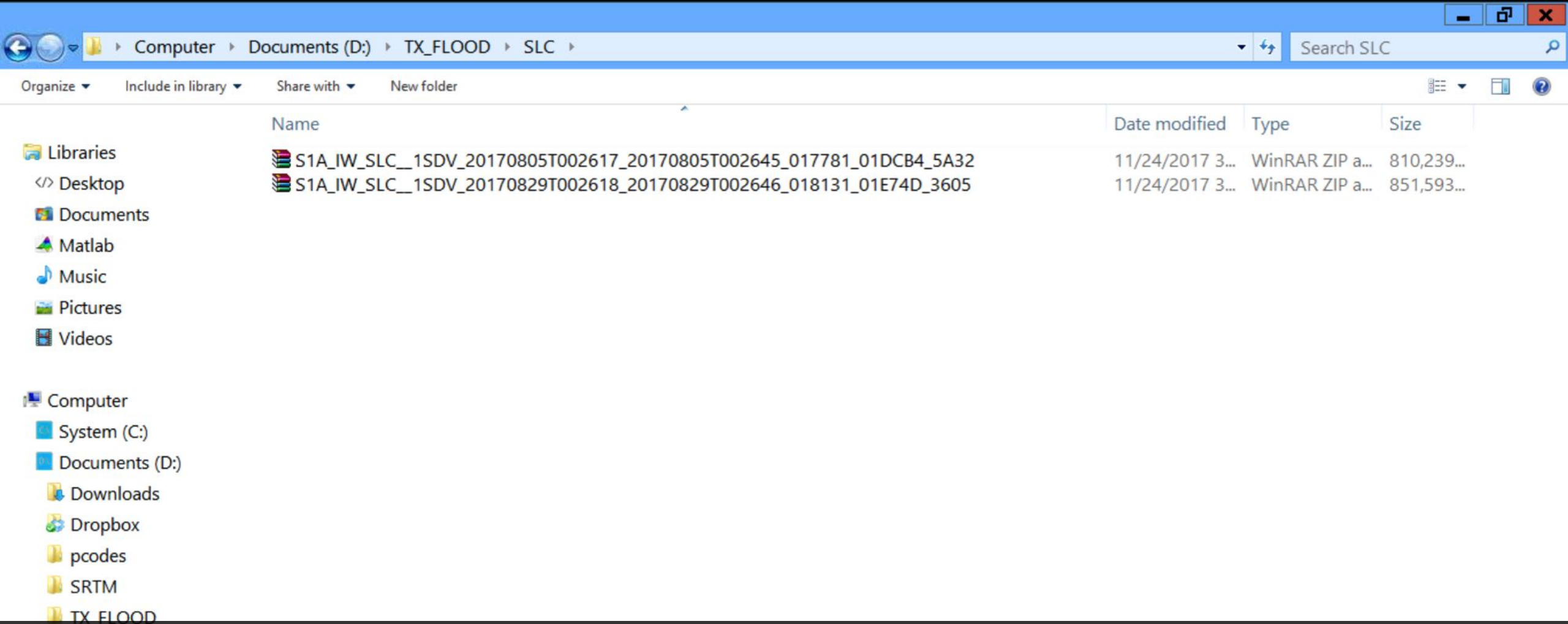
NAPA EARTHQUAKE: https://my.pcloud.com/publink/show?code=XZ1DnU7ZtMAo6EHeMopShqpY5keOnS2z1lkk



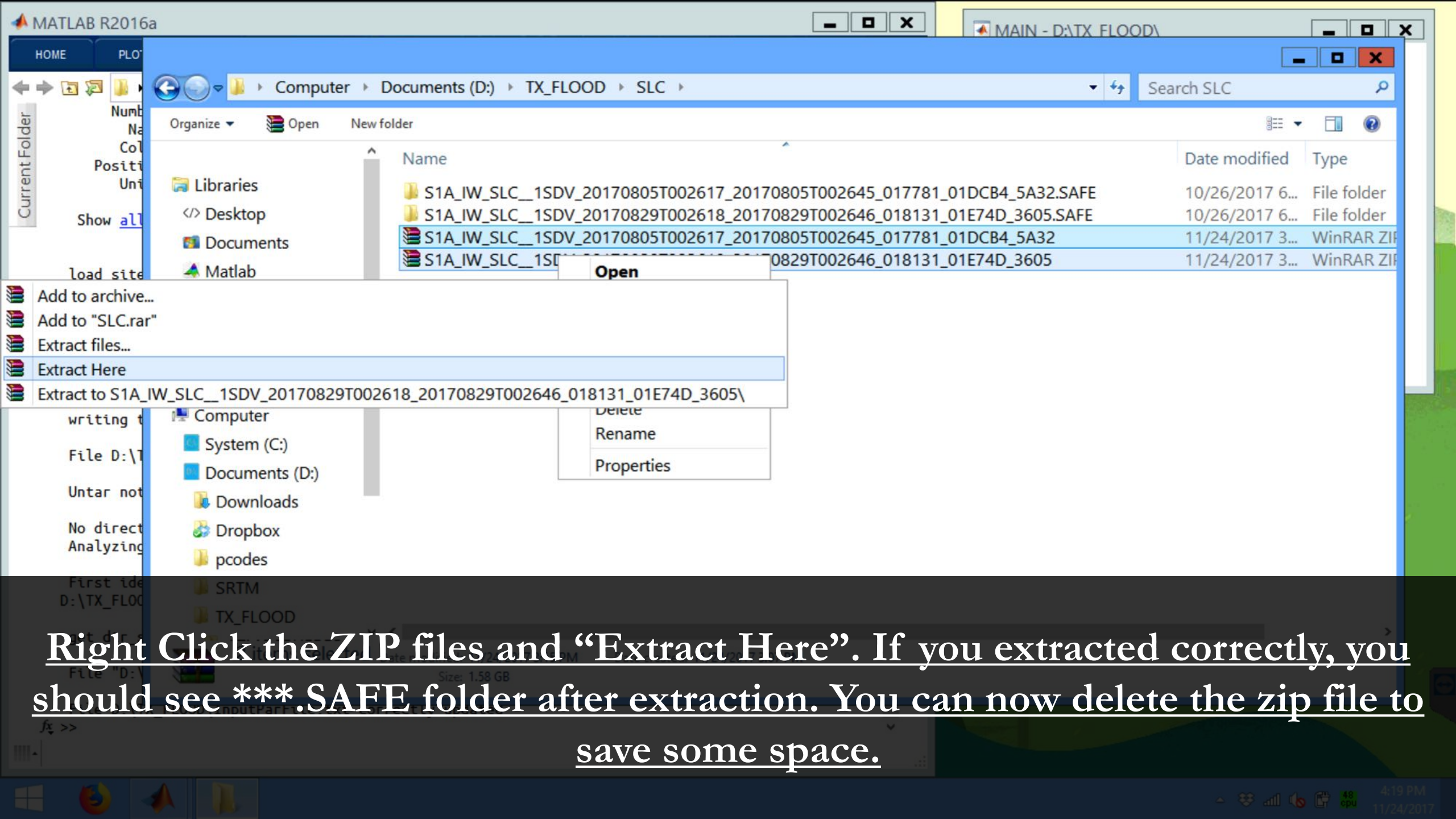
Download the two .zip file in the “SLC” folder.



Create a folder called "TX_FLOOD" on your PC. Inside that folder, create another folder called "SLC". Put the two zip file inside the SLC folder. Again, DON'T HAVE ANY SPACE IN THE PATH NAME WHERE YOU PUT THE TX_FLOOD FOLDER.

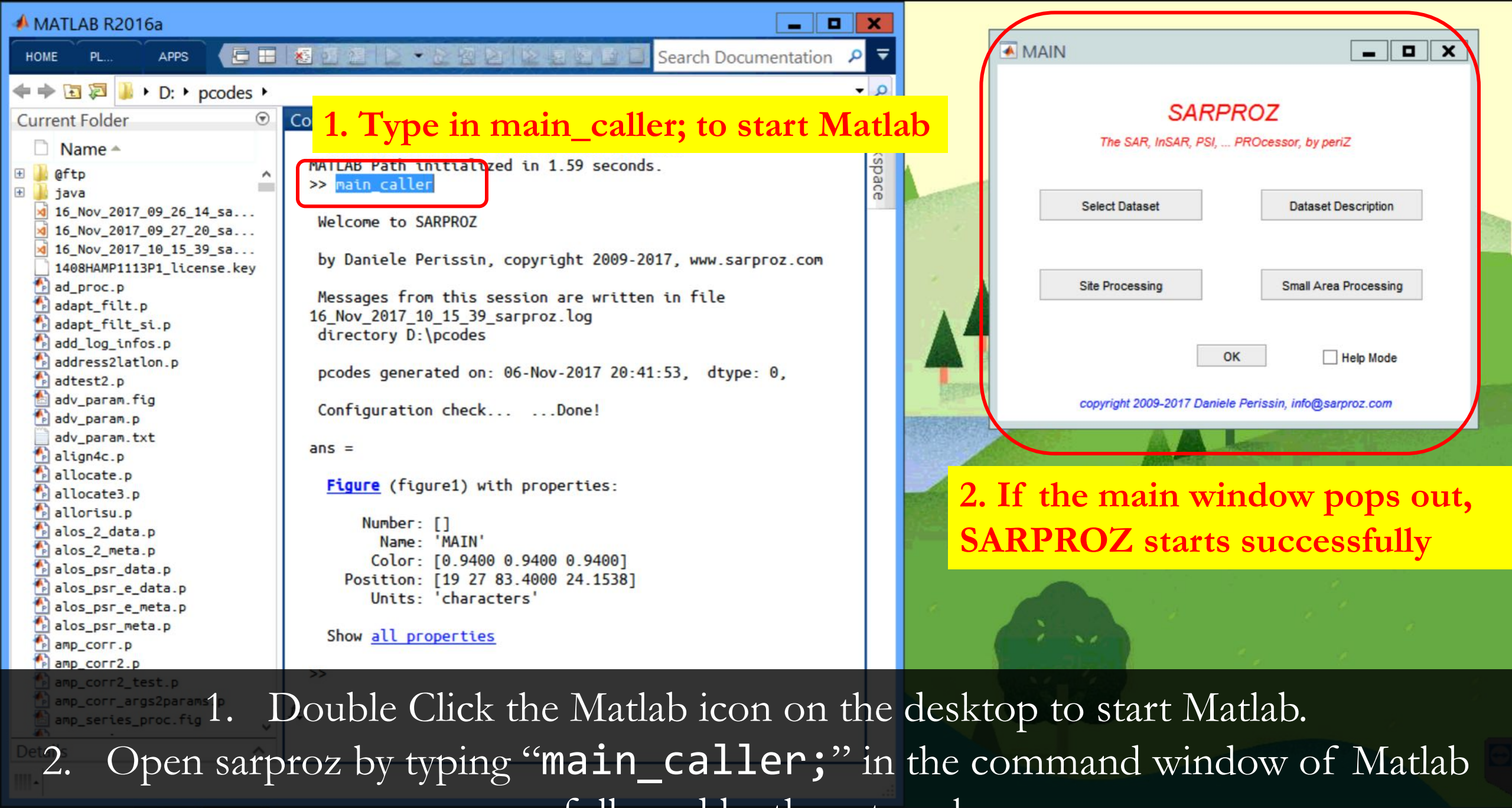


<u>PLEASE LEAVE AT LEAST 3.5GB AVAILABLE FOR THIS LAB!</u> (Later you will be instructed to delete unnecessary files during the process, but at one point you must have 3.5GB on disk to process all data!)

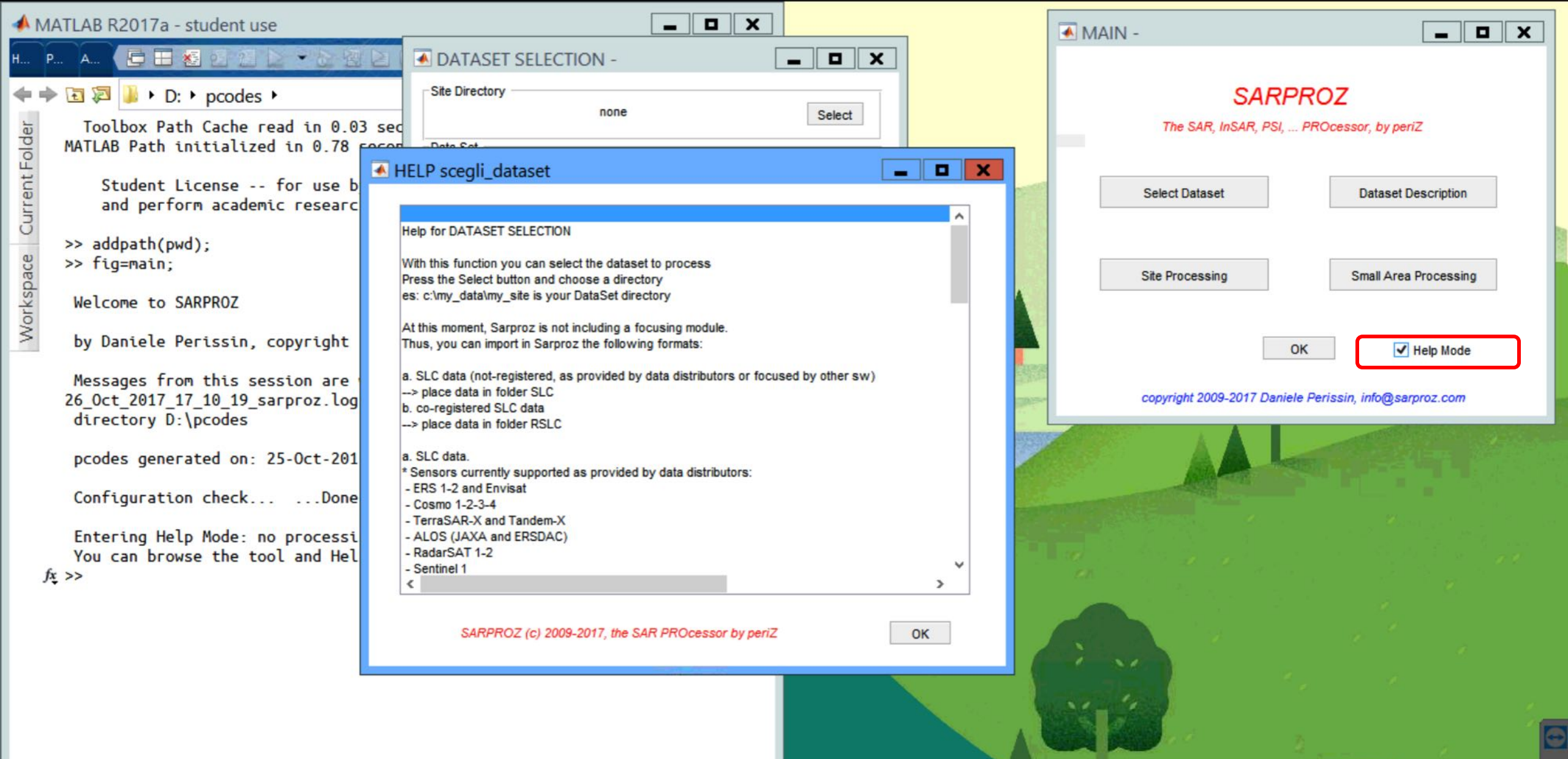


Right Click the ZIP files and "Extract Here". If you extracted correctly, you should see ***.SAFE folder after extraction. You can now delete the zip file to save some space.

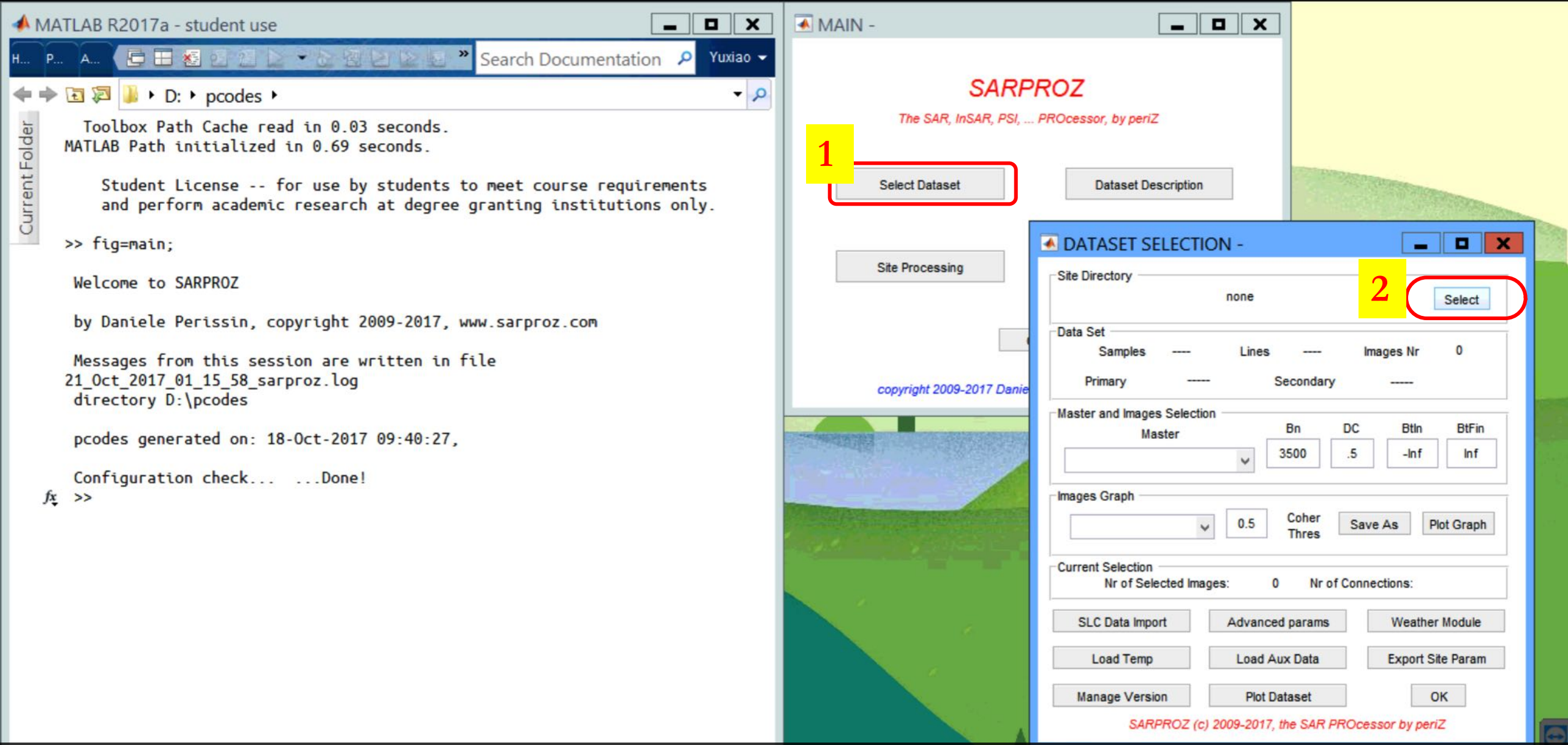
Part 1: Import
Synthetic **A**perture **R**adar (SAR)
Single-**L**ook **C**omplex (SLC) data



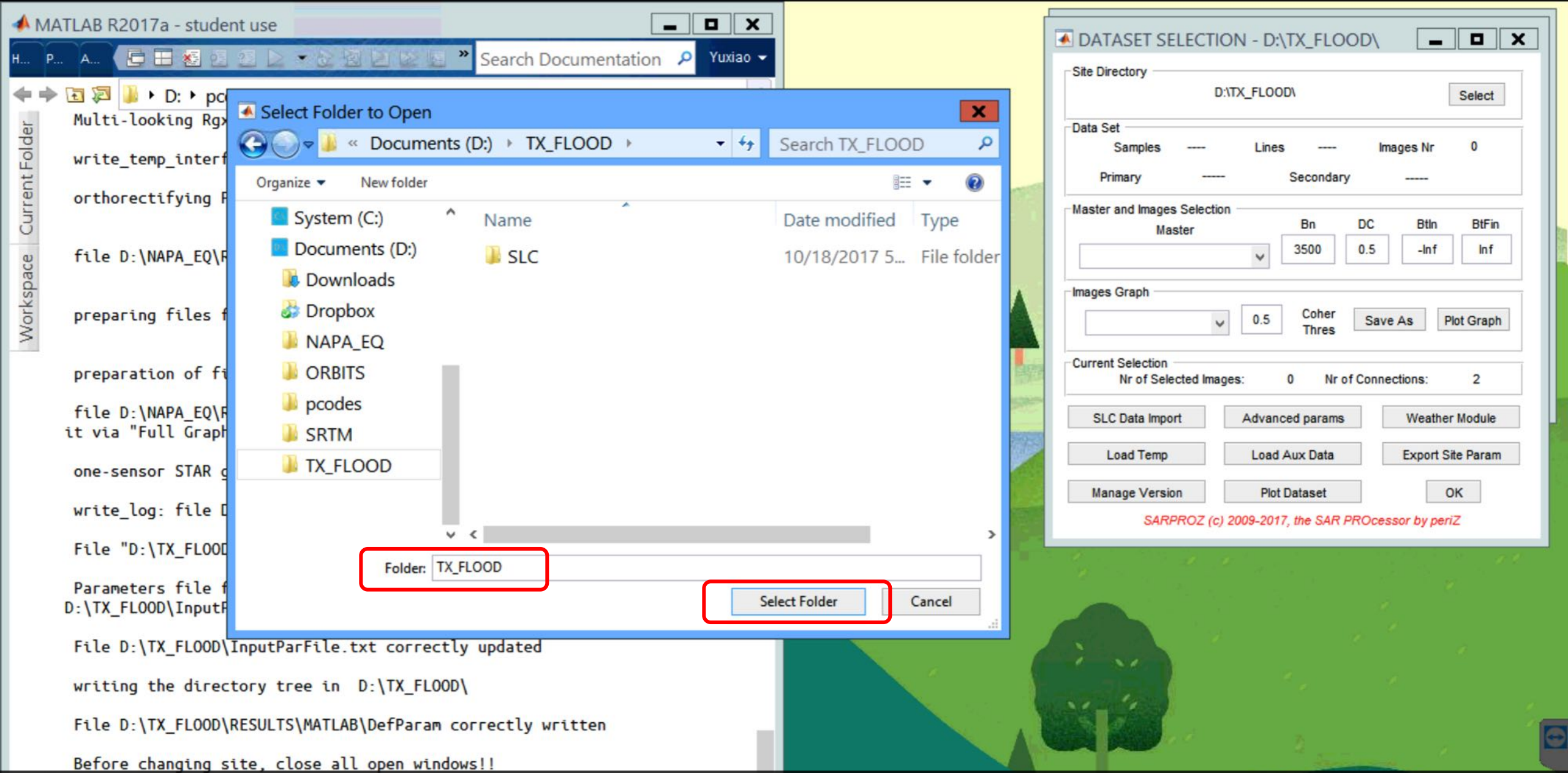
1. Double Click the Matlab icon on the desktop to start Matlab.
2. Open sarproz by typing "`main_caller;`" in the command window of Matlab followed by the return key.



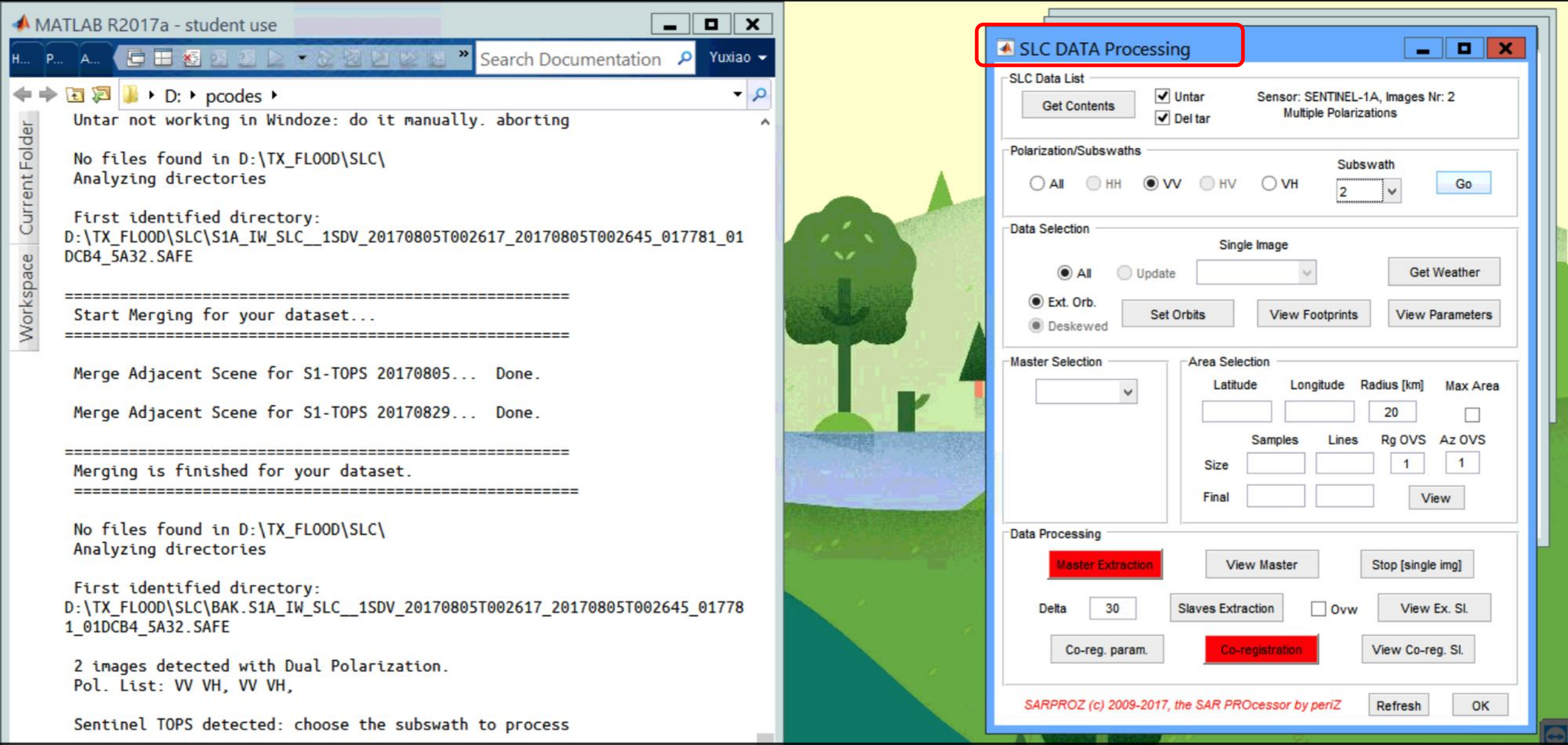
When the "Help Mode" is checked, a help window will pop out for different modules. The help mode is a quick guide for you to understand how each module works.



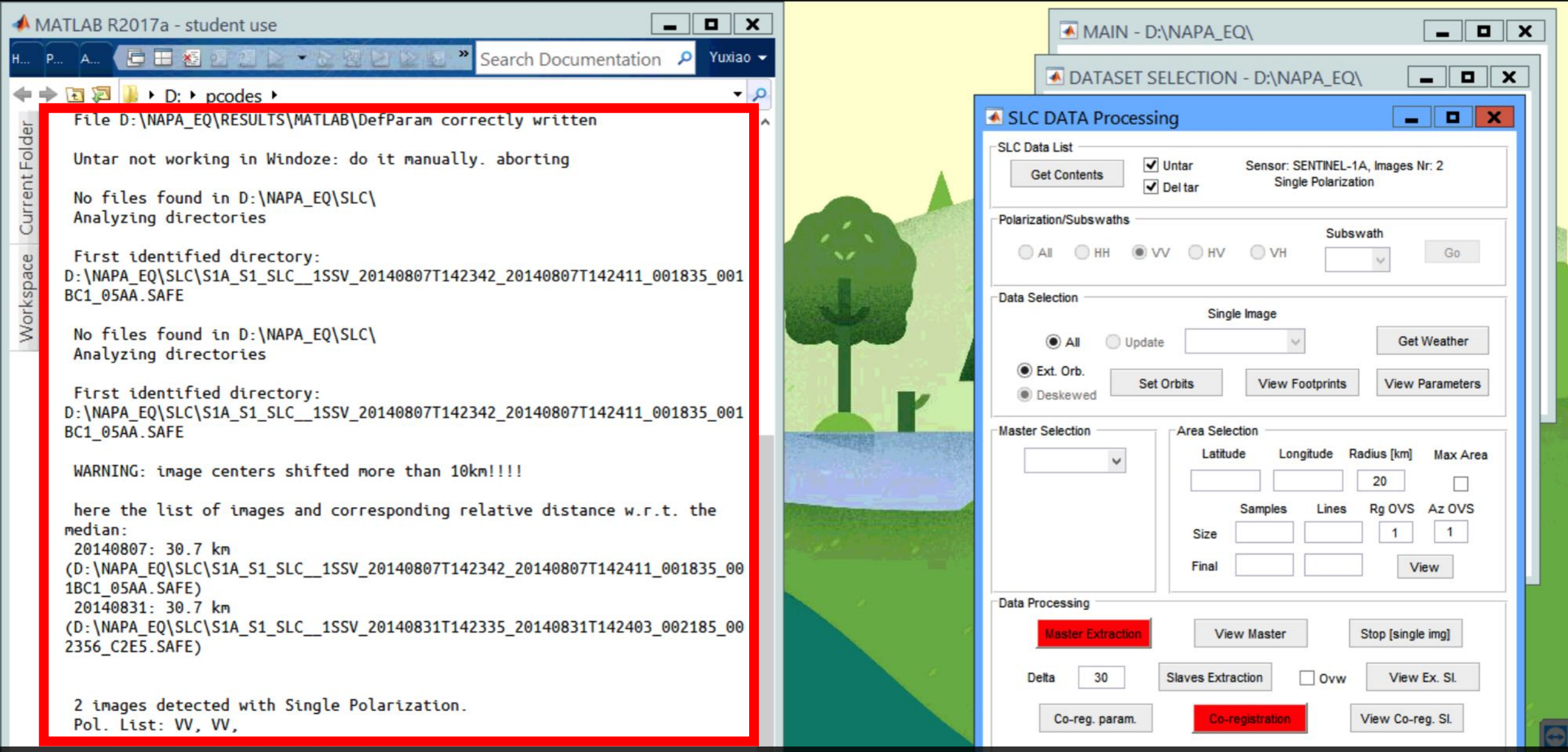
2. Click “Select Dataset” from the main window.
Then click “Select” to select your data.



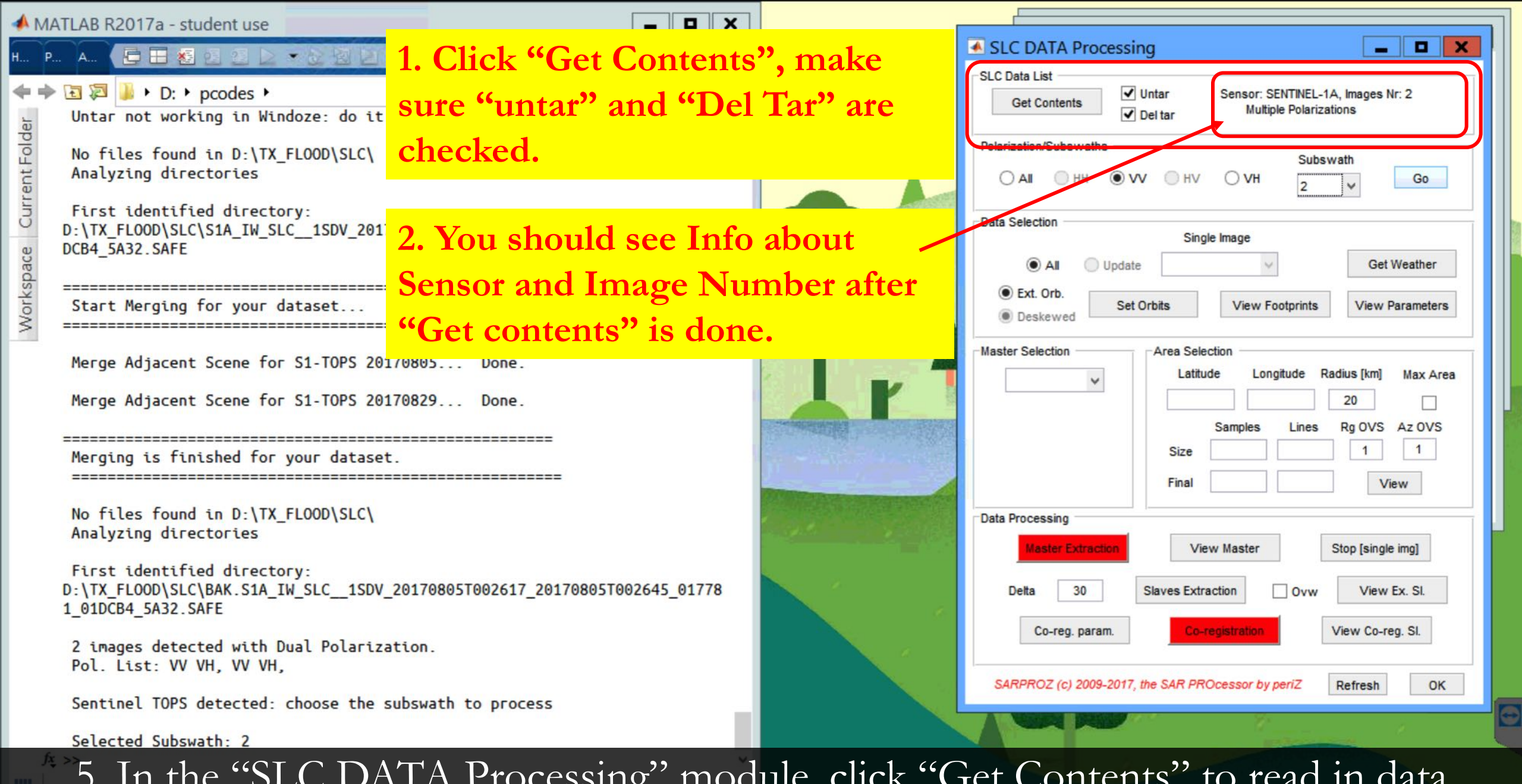
3. Select the folder "TX_FLOOD". There should be one "SLC" folder in it. Click "Select Folder".



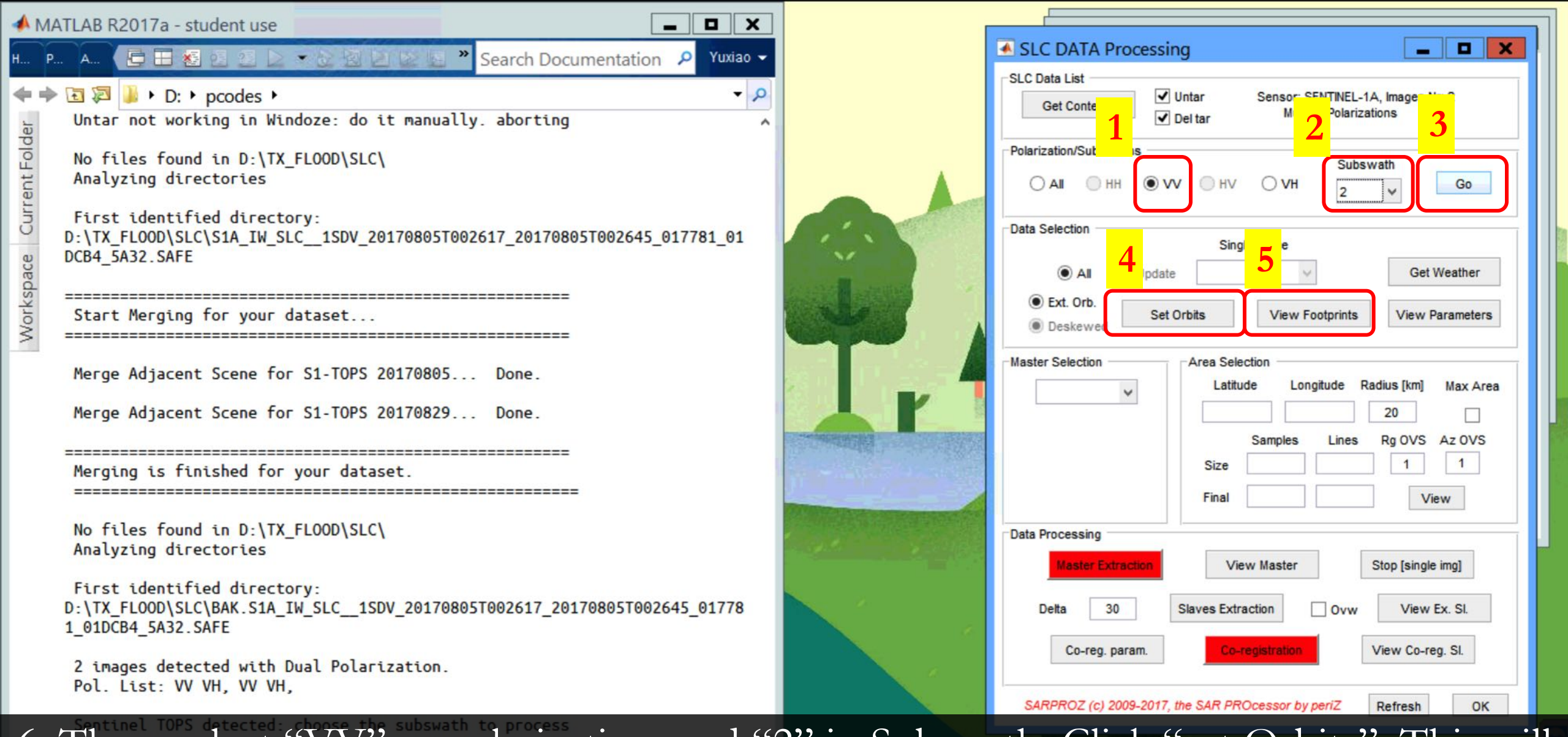
4. A module called “SLC Data Import” should automatically pop out. If not, you can click “SLC Data Import” in “Dataset Selection” module after you select the data.



Remember to ALWAYS KEEP THE COMMAND WINDOW OF MATLAB IN THE FRONT!!! The log contains key information regarding the process!!!



5. In the “SLC DATA Processing” module, click “Get Contents” to read in data parameters.

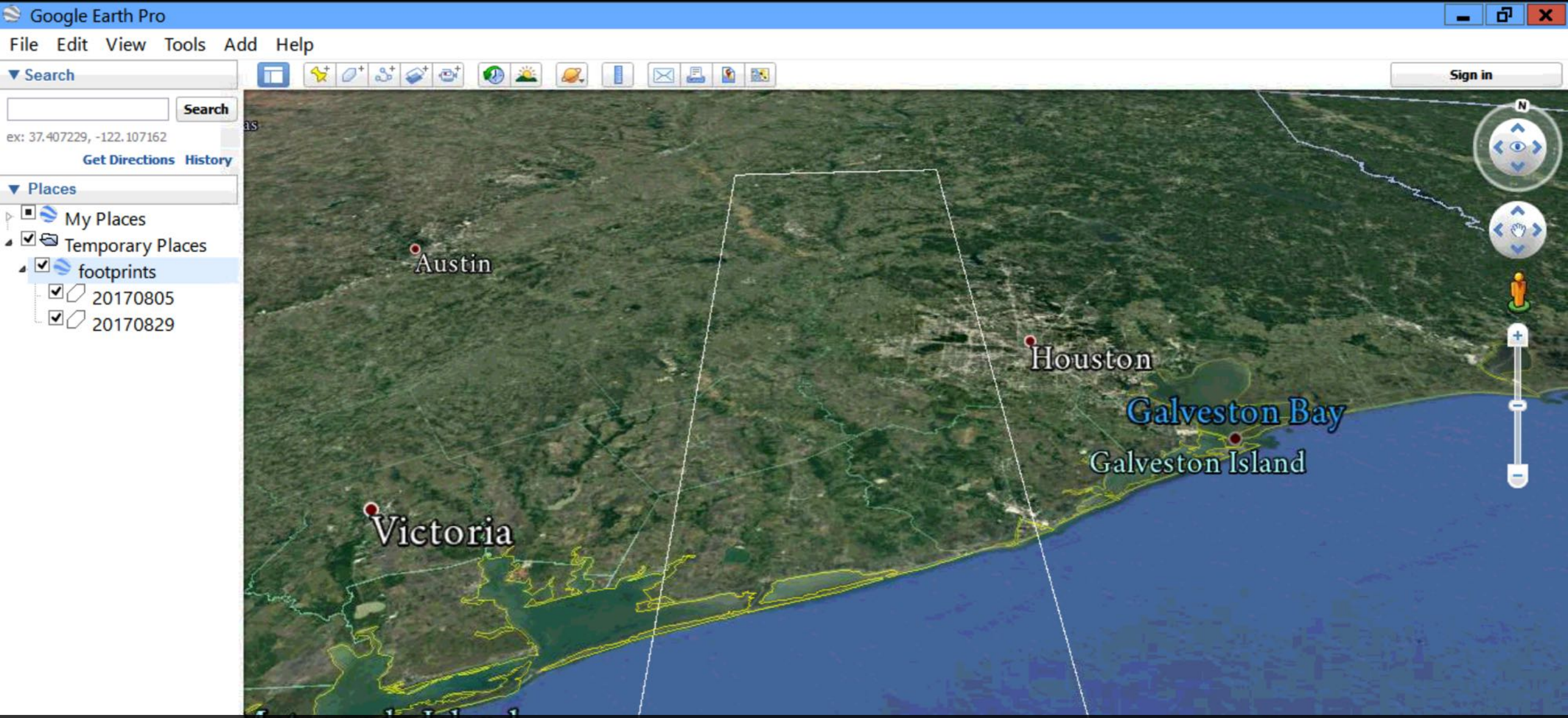


6. Then, select "VV" as polarization, and "2" in Subswath. Click "set Orbits". This will automatically download the satellite orbits, and calculate the footprint of SAR images. Difference subswaths has different footprints. You can "View Footprints".

Subswath

- Sentinel "TOPS" mode, or wide swath(IW) mode is a special mode that contains 3 subswath. This mode covers a larger area.
- Each subswath could be processed independently. You need to select the corresponding subswath in the software.
- You can then check the footprint of each subswath after "set orbits".
- In this sample data, only subswath 2 is provided. You can download other subswath online as well.

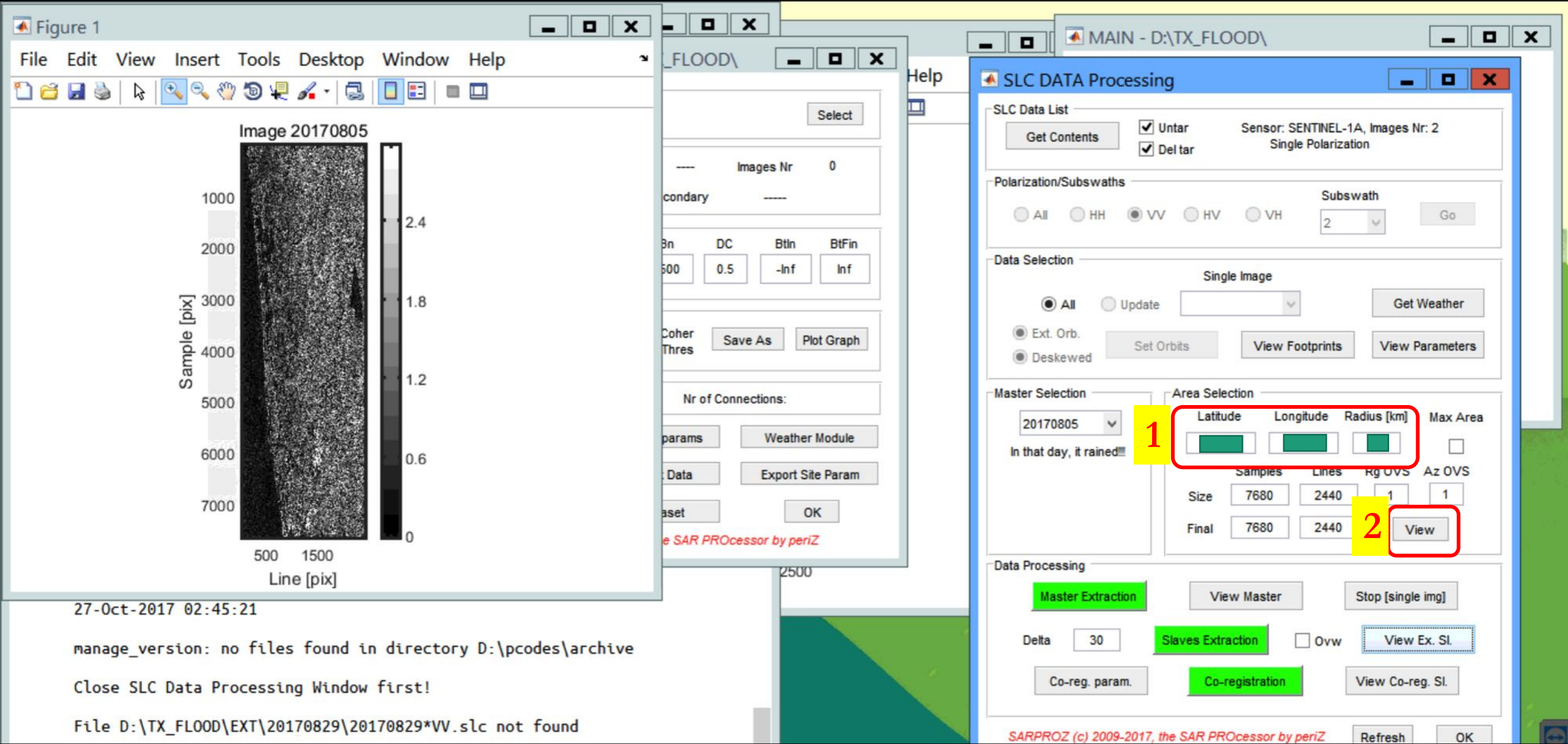
  - https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar/acquisition-modes/interferometric-wide-swath



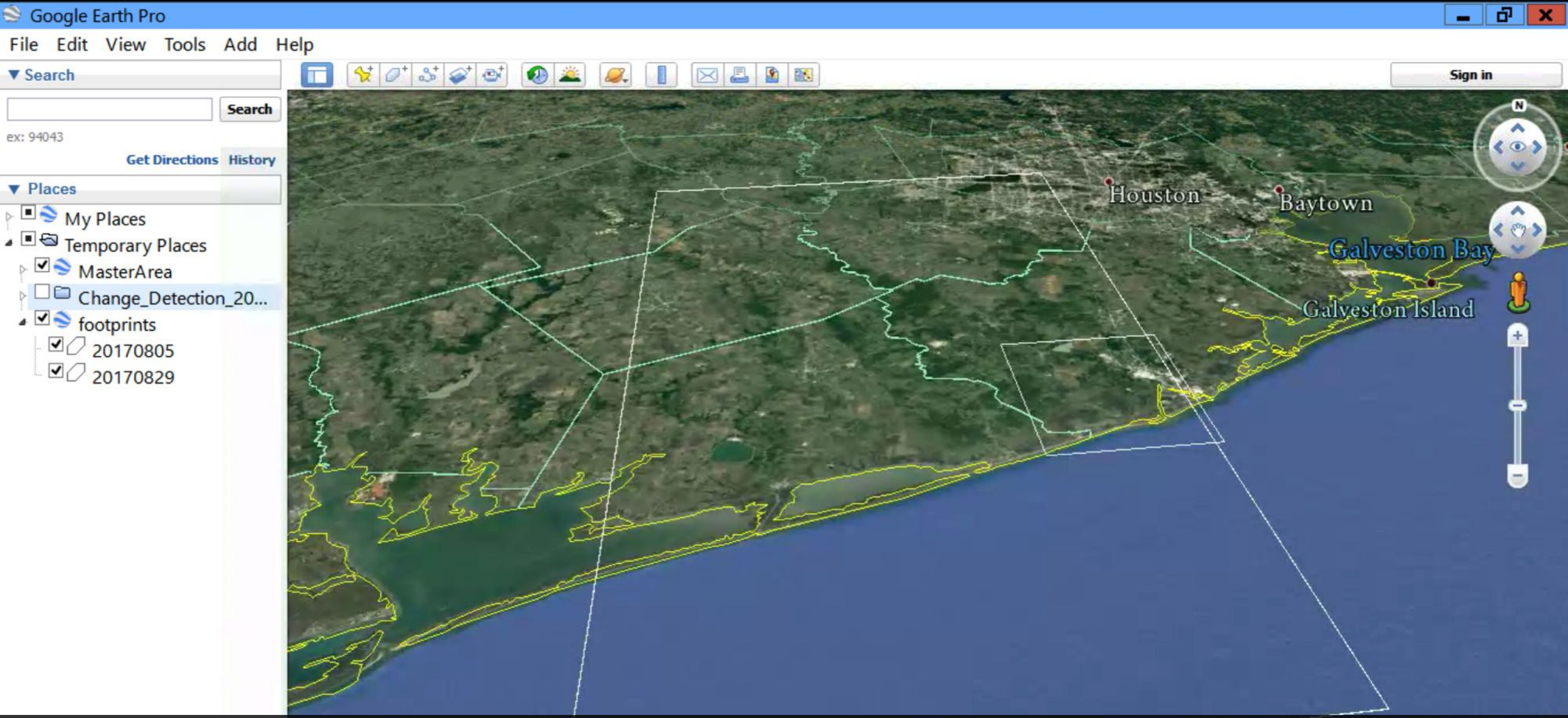
Click "View Footprints" to see the footprints of your image(s) on Google Earth. If Google Earth do not start automatically, Go to "TX_FLOOD/RESULTS/GEO/" and double click "footprints.kml" to open.

Select your own Area of Interest (AOI)

1. In this tutorial, you are asked to select your own AOI by putting down your own AOI center latitude, longitude and area radius.
2. Go to this website to understand the details about the flood caused by Hurricane Harvey.
3. **Select a center coordinates:**
   - Limit your latitude between 28.7° and 29.0°;
   - Limit your longitude between -96.0° and -95.7° (a negative sign just means the west hemisphere);
   - Limit your range between 12km and 16km (a sufficient area is required to analysis the flood. On the other side, due to disk space restriction, you need to limit the size of extracted area).
   - Make sure your selected AOI is located at coastal area.

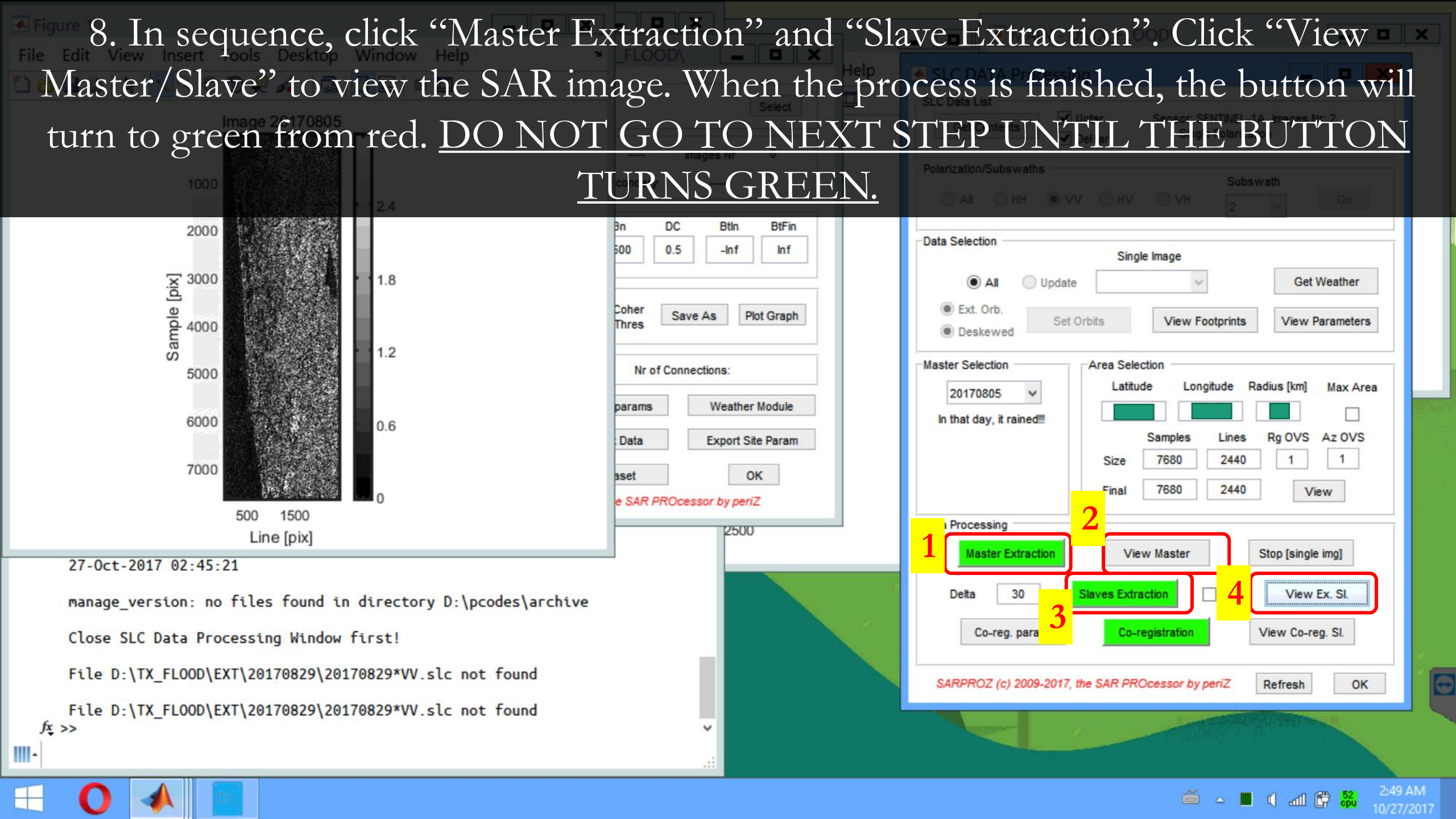


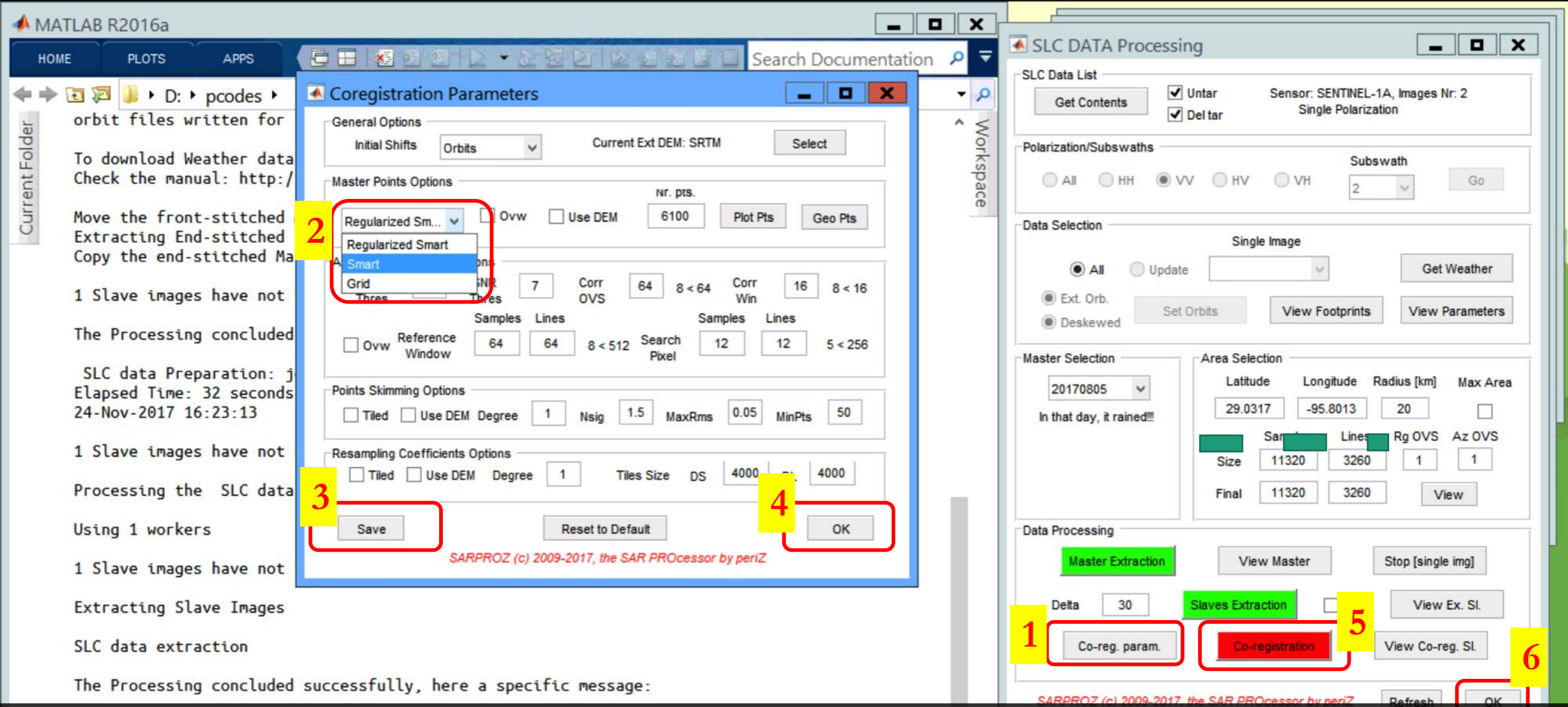
7. In “Area Selection”, input your value for latitude, longitude and radius based on the info from previous page. You can click “View” to see your selected AOI.



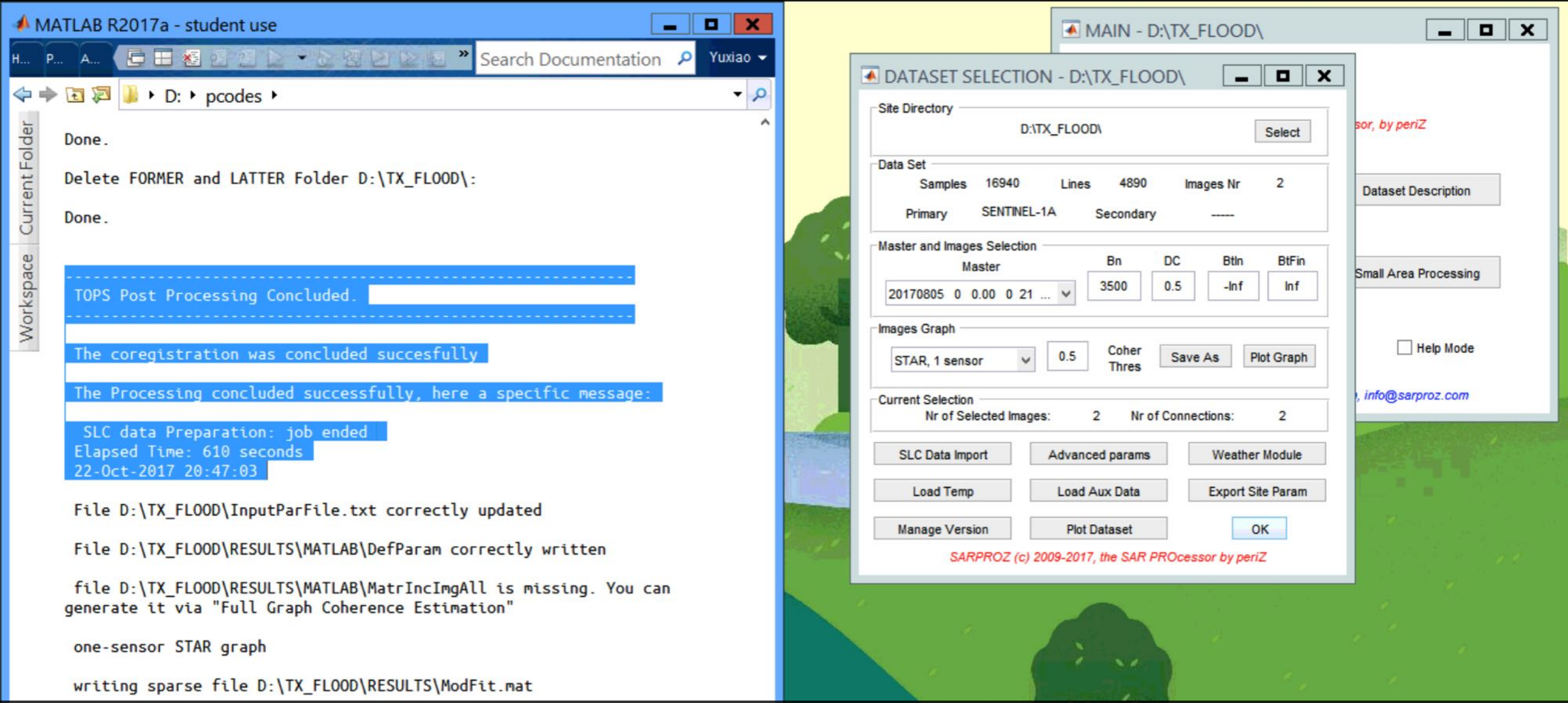
Click "View" to see the area you have selected (to process). If Google Earth do not start automatically, Go to "TX_FLOOD/RESULTS/GEO/" and double click "MasterArea.kml" to open.

8. In sequence, click “Master Extraction” and “Slave Extraction”. Click “View Master/Slave” to view the SAR image. When the process is finished, the button will turn to green from red. <u>DO NOT GO TO NEXT STEP UNTIL THE BUTTON TURNS GREEN.</u>

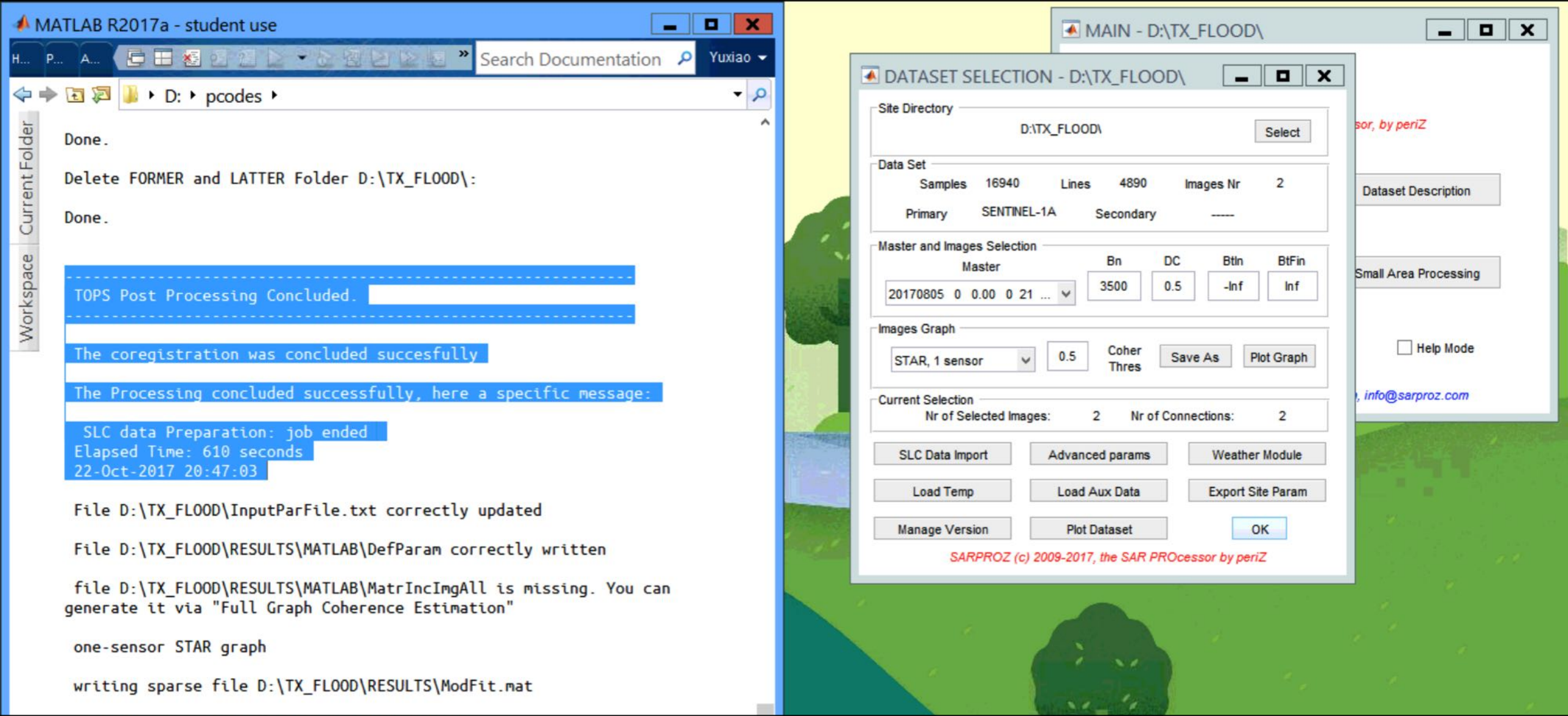




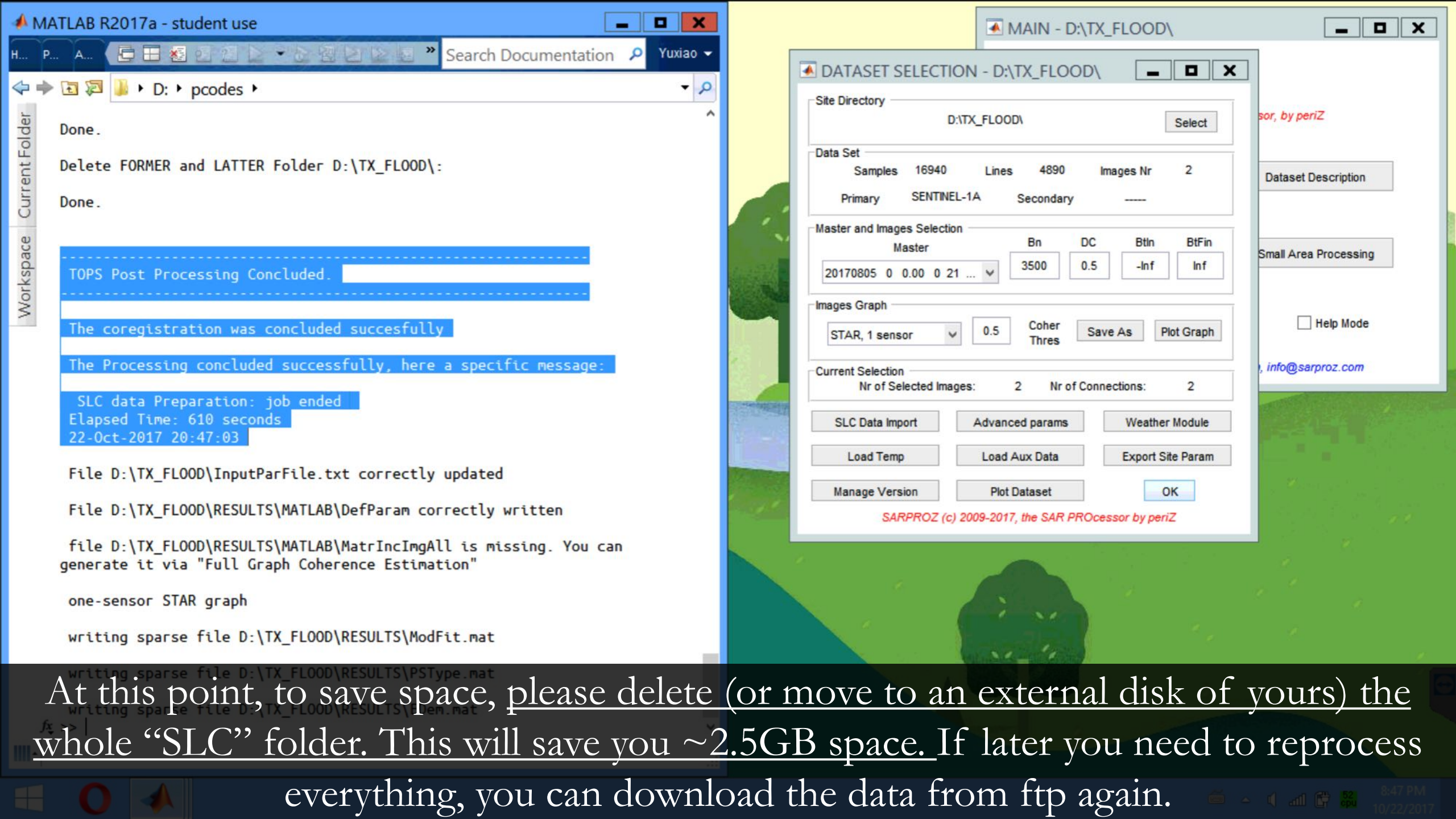
9. Click "Co-reg(istration) Param(eter)". In the popped out panel, Choose "Smart" in "Master Points Options". Click "Save" to save the parameters. Click "OK" to close this window. Afterwards, click "Co-registration" to start coregistering two images.



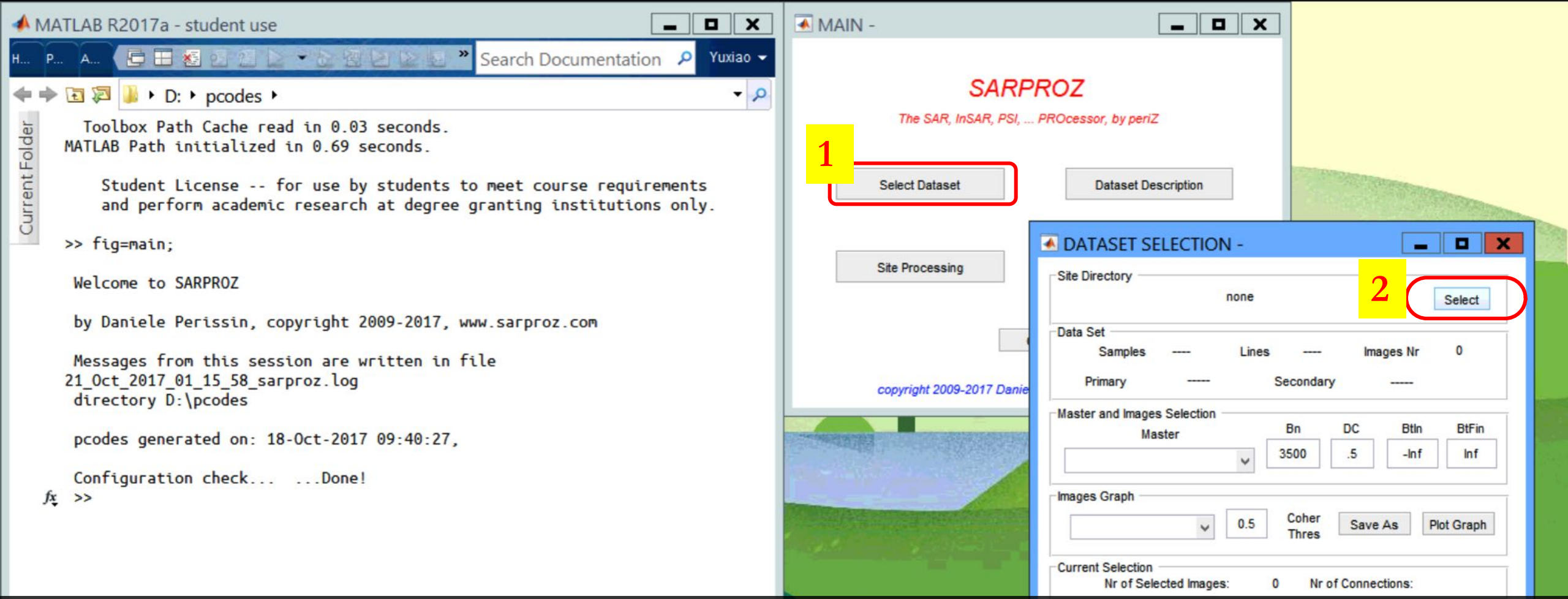
9. (contd) The "Coregistration" button will turn green and you will see the success message in command window of Matlab after the process is completed. Click "OK" to close the "SLC Data Processing" panel.



Coregistration will "align" all images pixel-by-pixel. This will allow us to compare the images pixel-by-pixel.

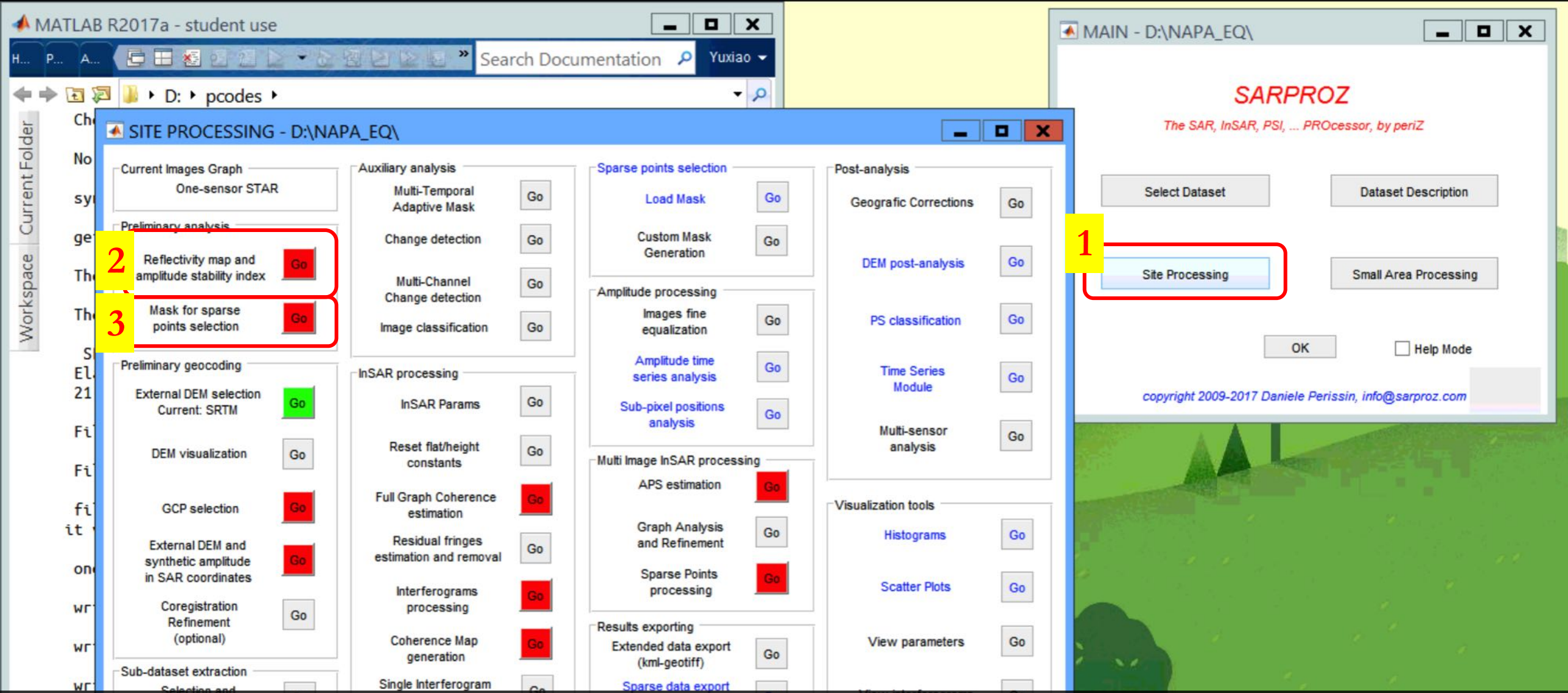


At this point, to save space, please delete (or move to an external disk of yours) the whole "SLC" folder. This will save you ~2.5GB space. If later you need to reprocess everything, you can download the data from ftp again.

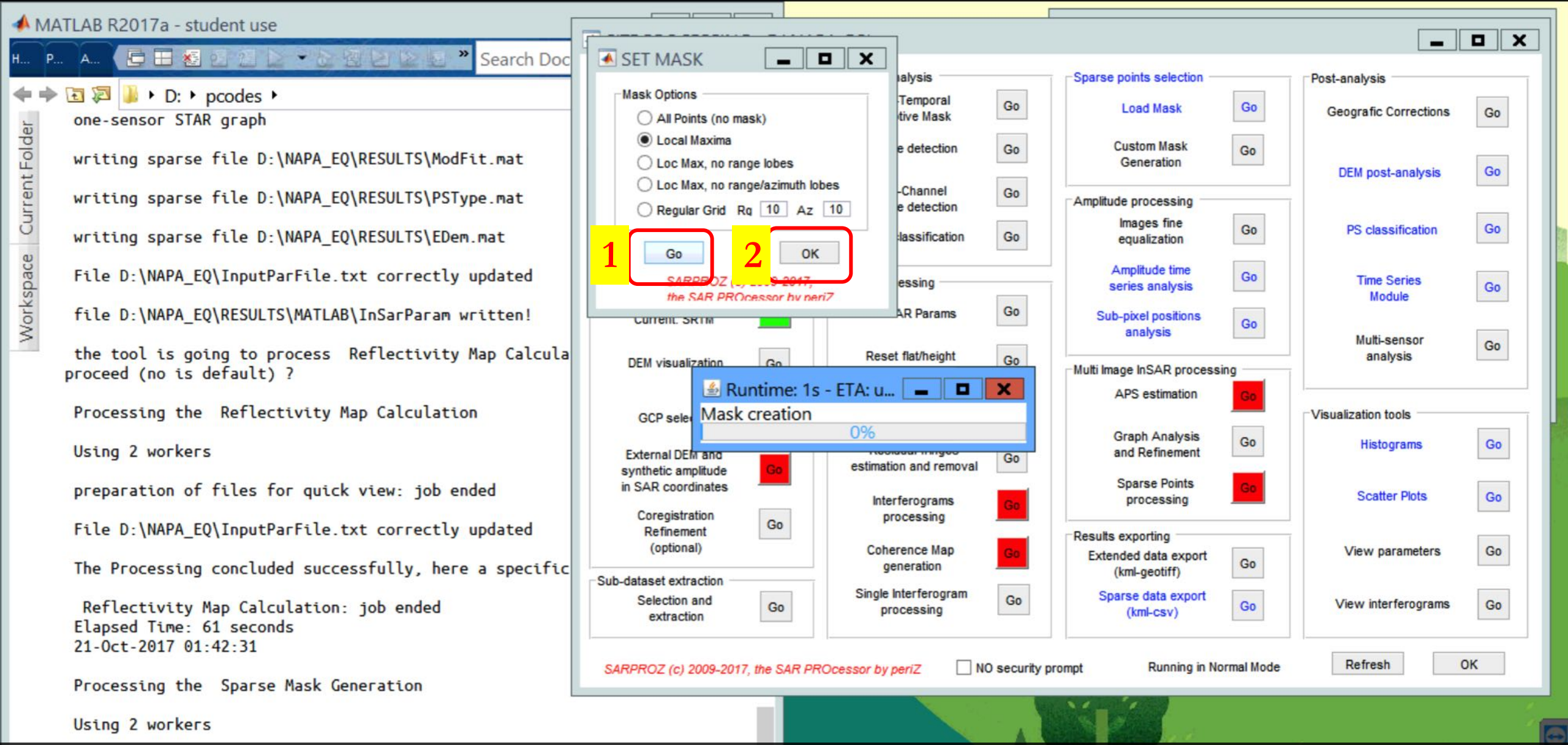


After the “SLC Data Import” is finished, all the processed data are stored in your TX_FLOOD folder. It means you can close sarproz and reload your data anytime. There is no “saving” needed in sarproz. Just click “Select Dataset”-> “Select” -> Select ”TX_FLOOD” folder to load your dataset every time you start sarproz.

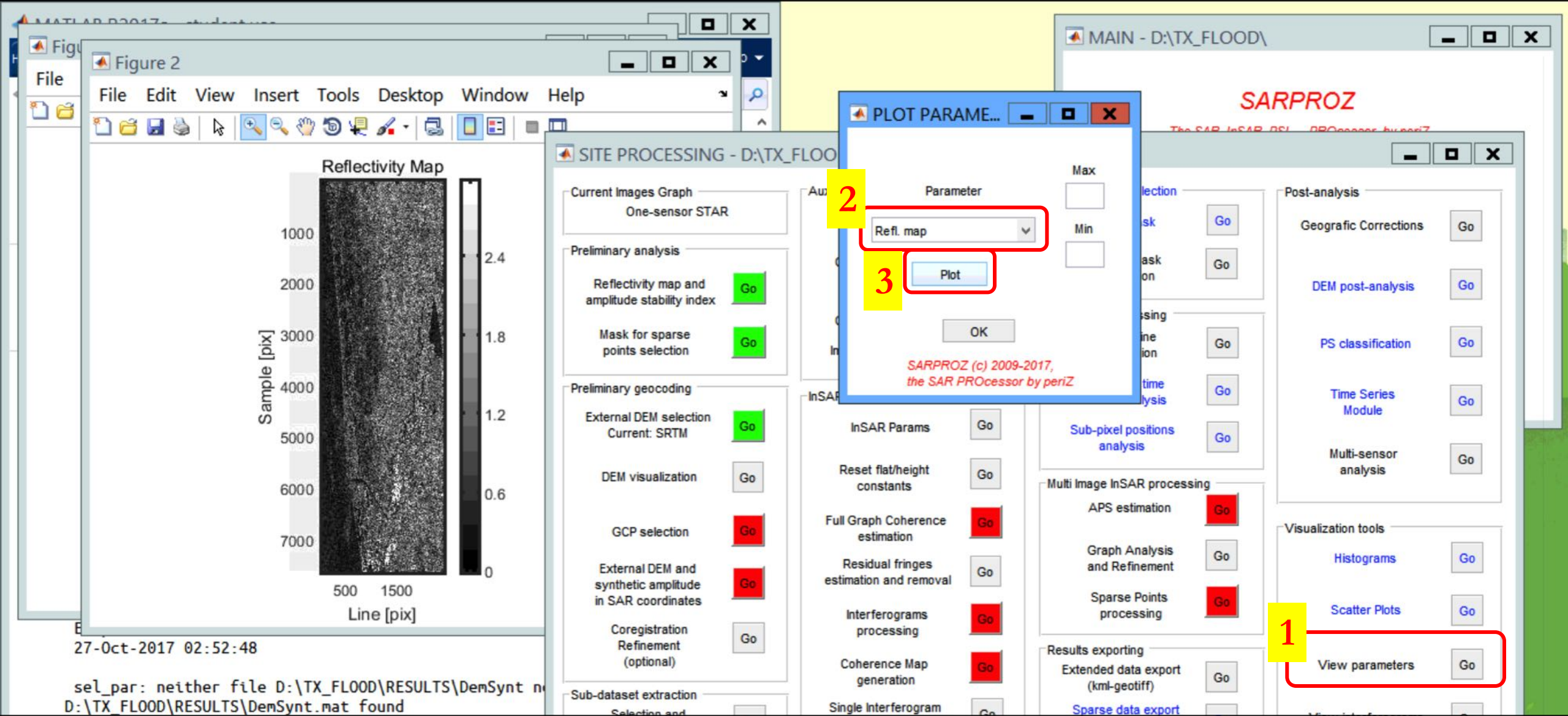
Part 2: Pre-processing for Change Detection



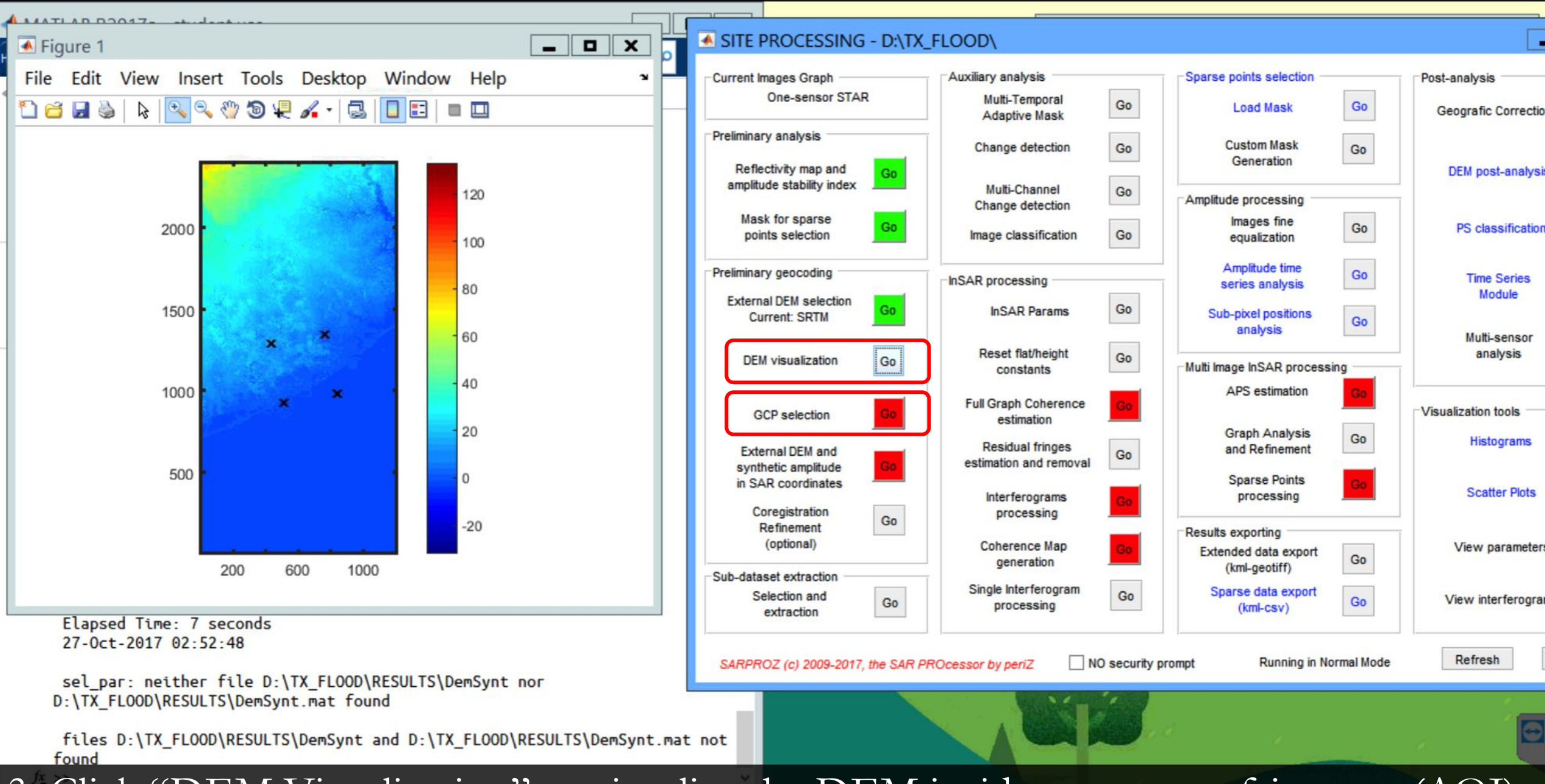
1. Click “Site Processing” in the main window. In the new site processing window, click “Reflectivity map and amplitude stability Index” to generate reflectivity map. Wait until the button turns green before going to the next step.



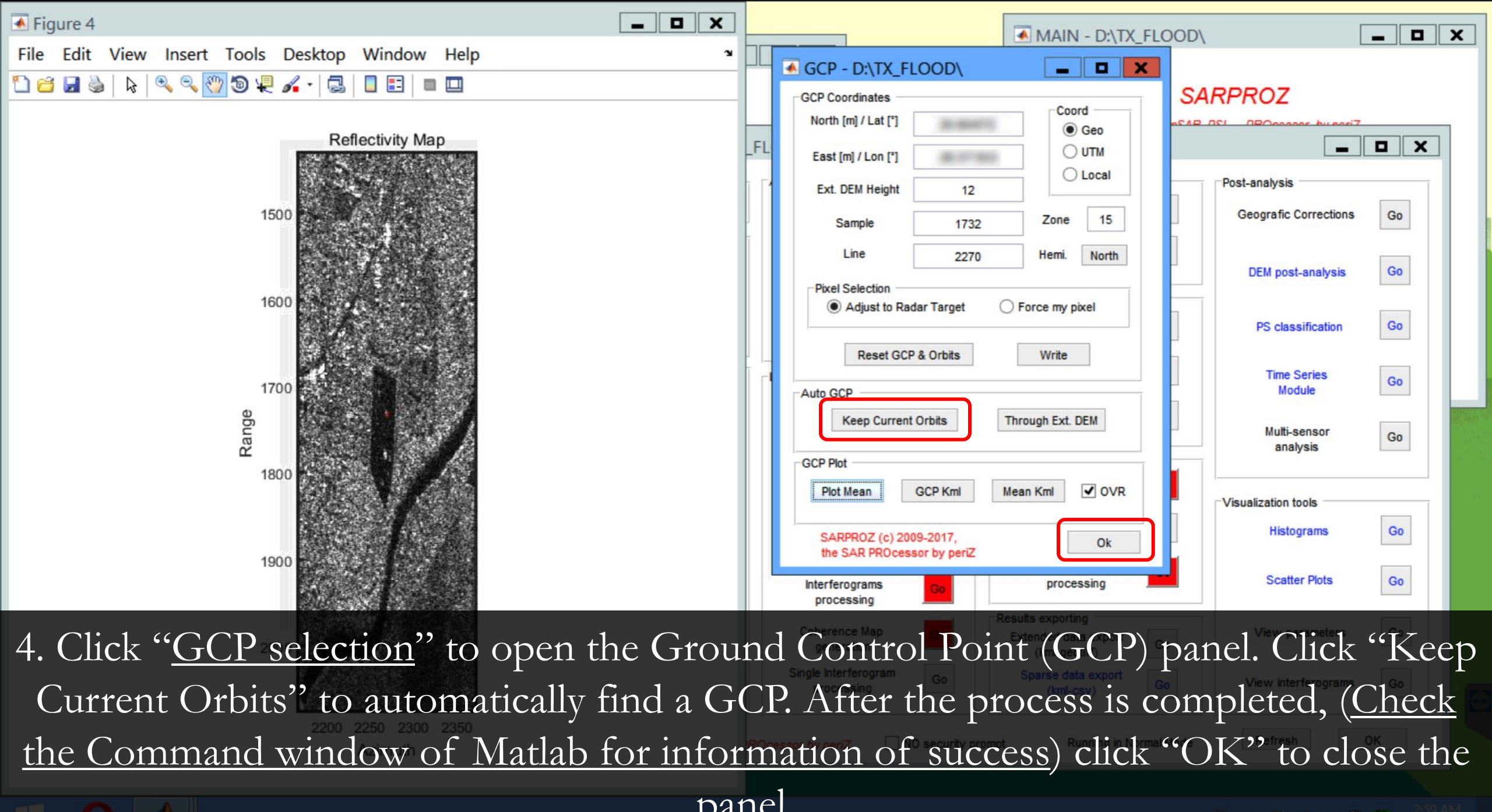
2. Click “Mask for sparse points selection” and Click “Go” in the new popped up window. Click “OK” to close the window when it is finished.



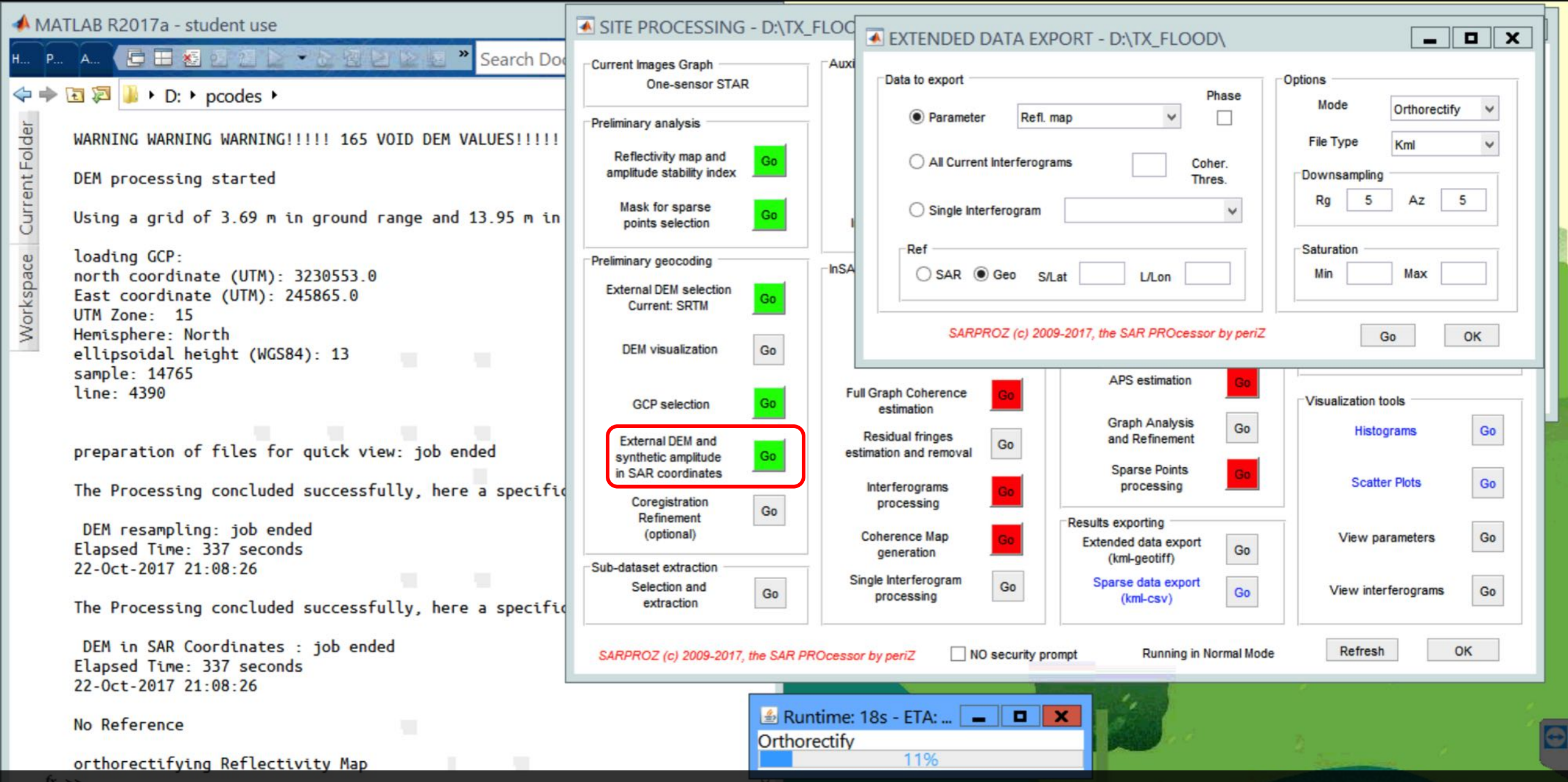
You can click "View Parameters" in visualization tools panel. Then select "Refl. Map" in parameter and click "plot" to plot it. You can also go to "TX_FLOOD/RESULT" and open "MeanFirst.jpg" to check the jpeg format of reflectivity map.



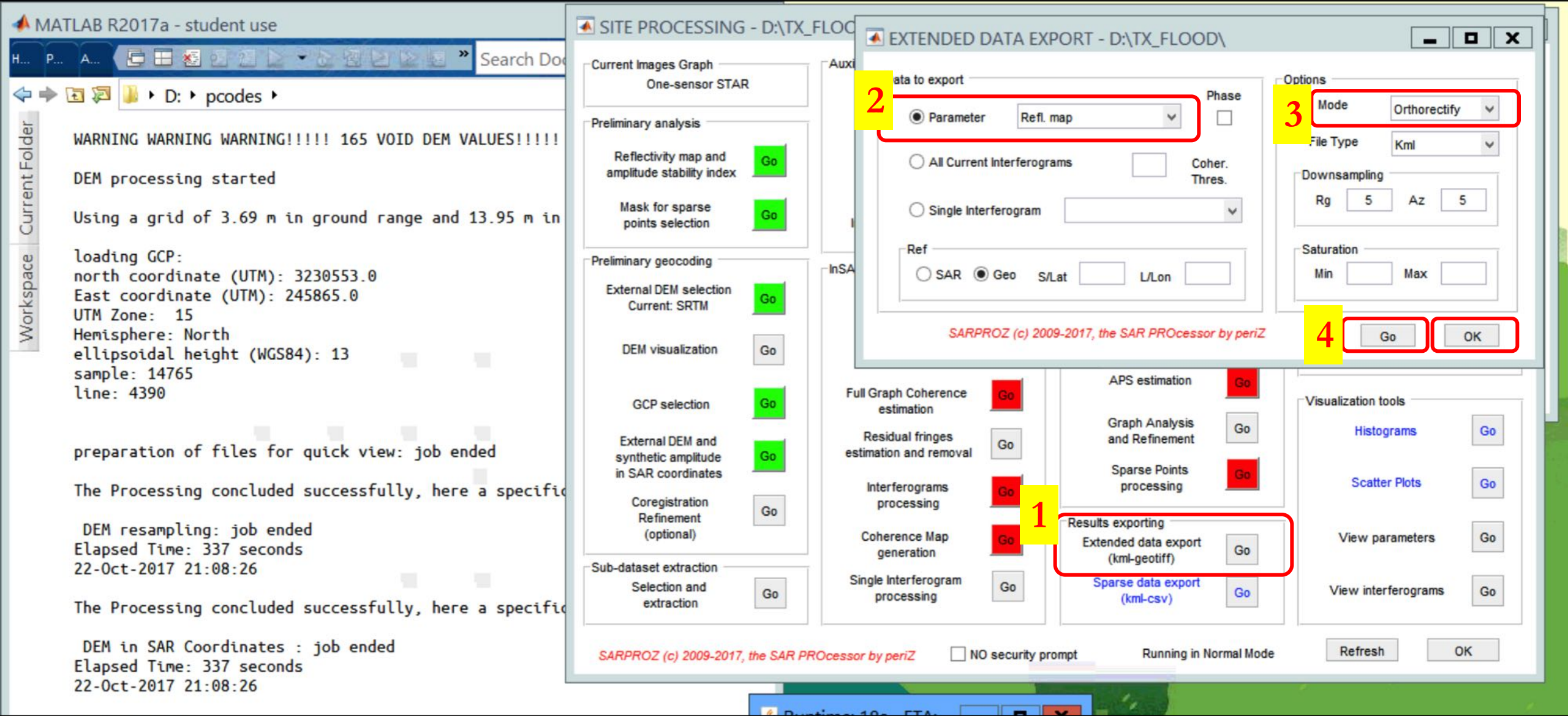
3. Click "DEM Visualization" to visualize the DEM inside your area of interest (AOI). The four black cross indicates the four corner of AOI.



4. Click "GCP selection" to open the Ground Control Point (GCP) panel. Click "Keep Current Orbits" to automatically find a GCP. After the process is completed, (Check the Command window of Matlab for information of success) click "OK" to close the panel.

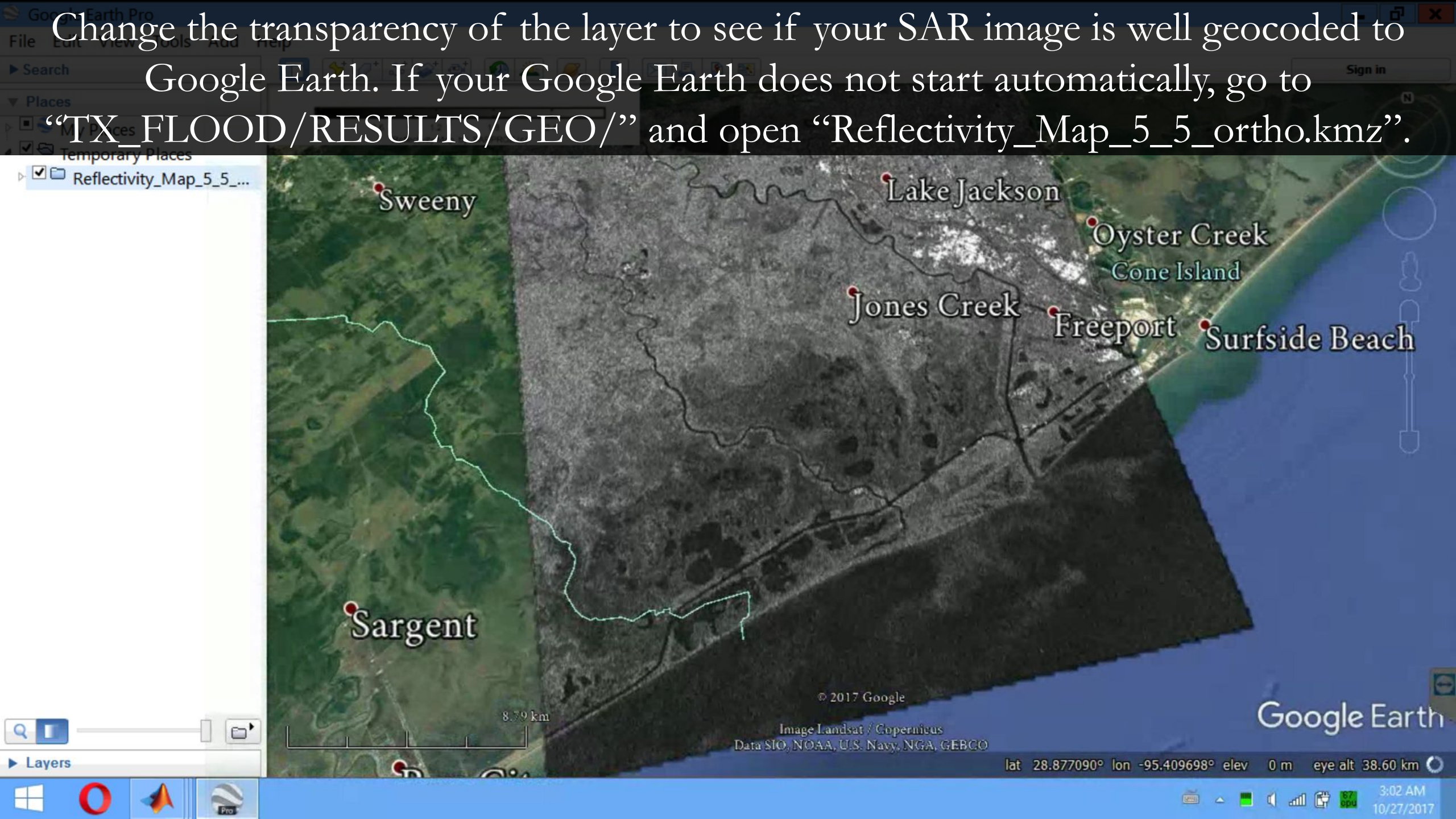


5. Click “External DEM and synthetic amplitude in SAR coordinates”.



6. We need to **geocode the SAR image to Google Earth.** To do so, click "Extended data export" in "Results exporting" panel. Choose "Refl. Map" in Parameter; Choose "Orthorectify" in Mode, Press "Go".

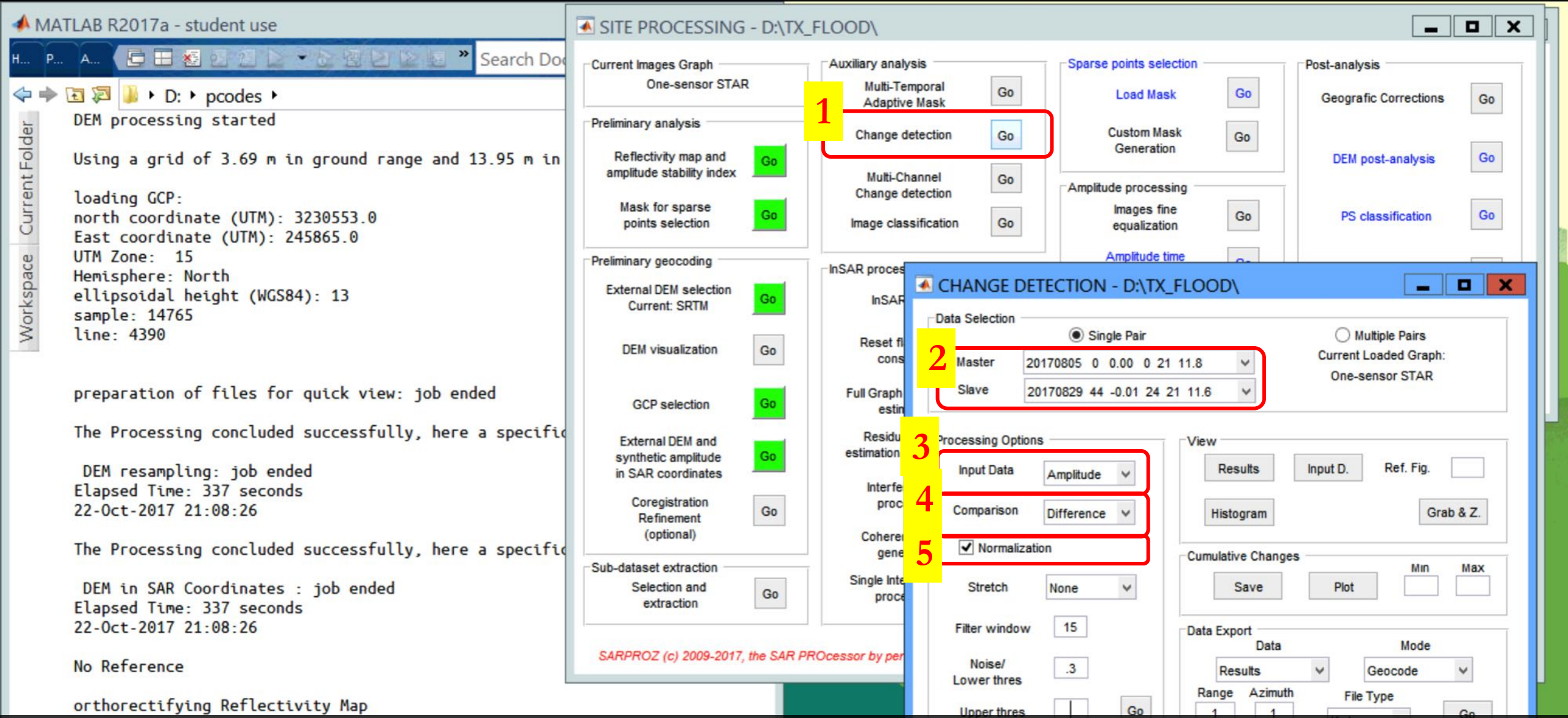
Change the transparency of the layer to see if your SAR image is well geocoded to Google Earth. If your Google Earth does not start automatically, go to "TX_FLOOD/RESULTS/GEO/" and open "Reflectivity_Map_5_5_ortho.kmz".



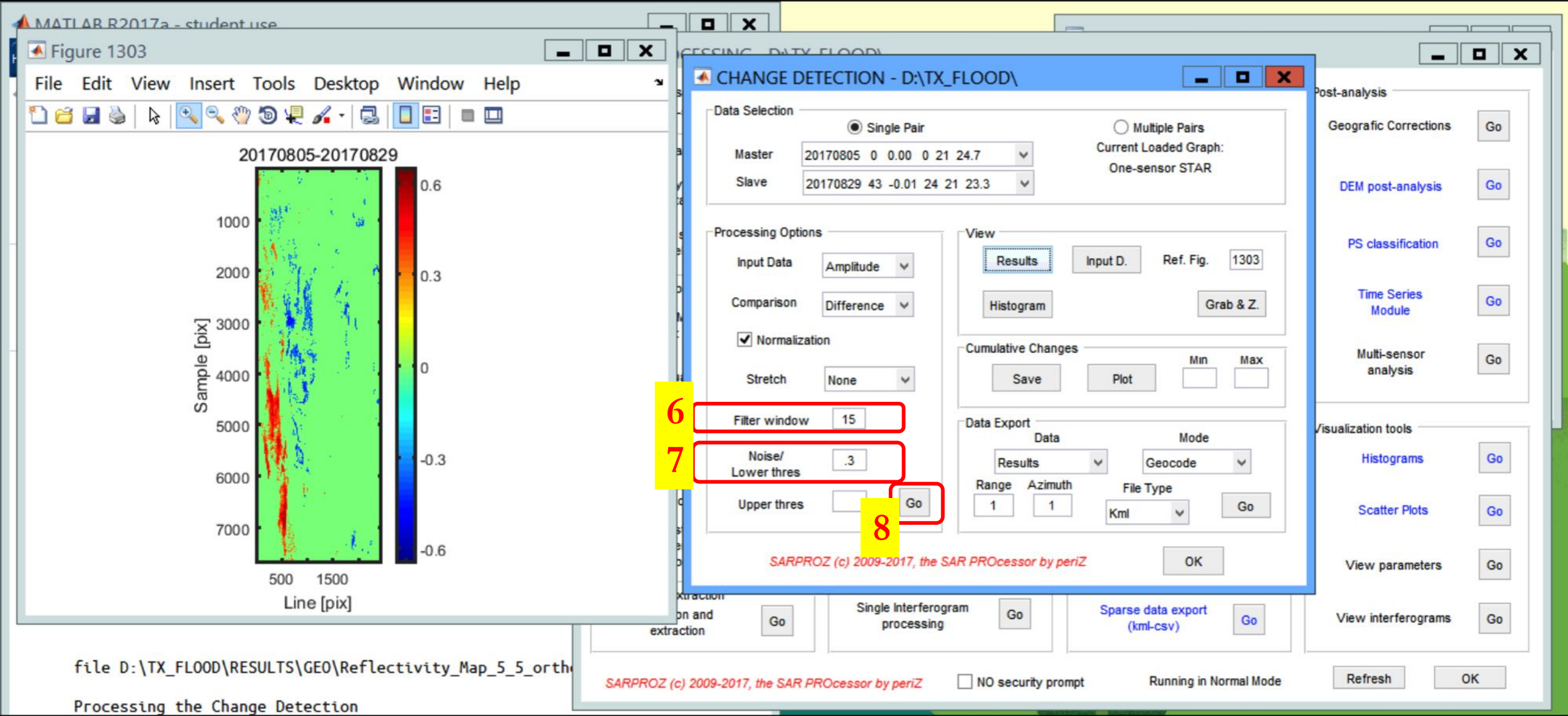
Part 3: Change(flood) Detection

Change Detection

- The change detection is straightforward. It compares the intensity of the two SAR SLC images and calculate the difference.
- This is especially useful for flood detection.
- Go to "TX_FLOOD\FITTED" folder, compare "20170805.jpeg" and "20170829.jpeg". Get an intuitive understanding of how the flood is changing the SAR image.

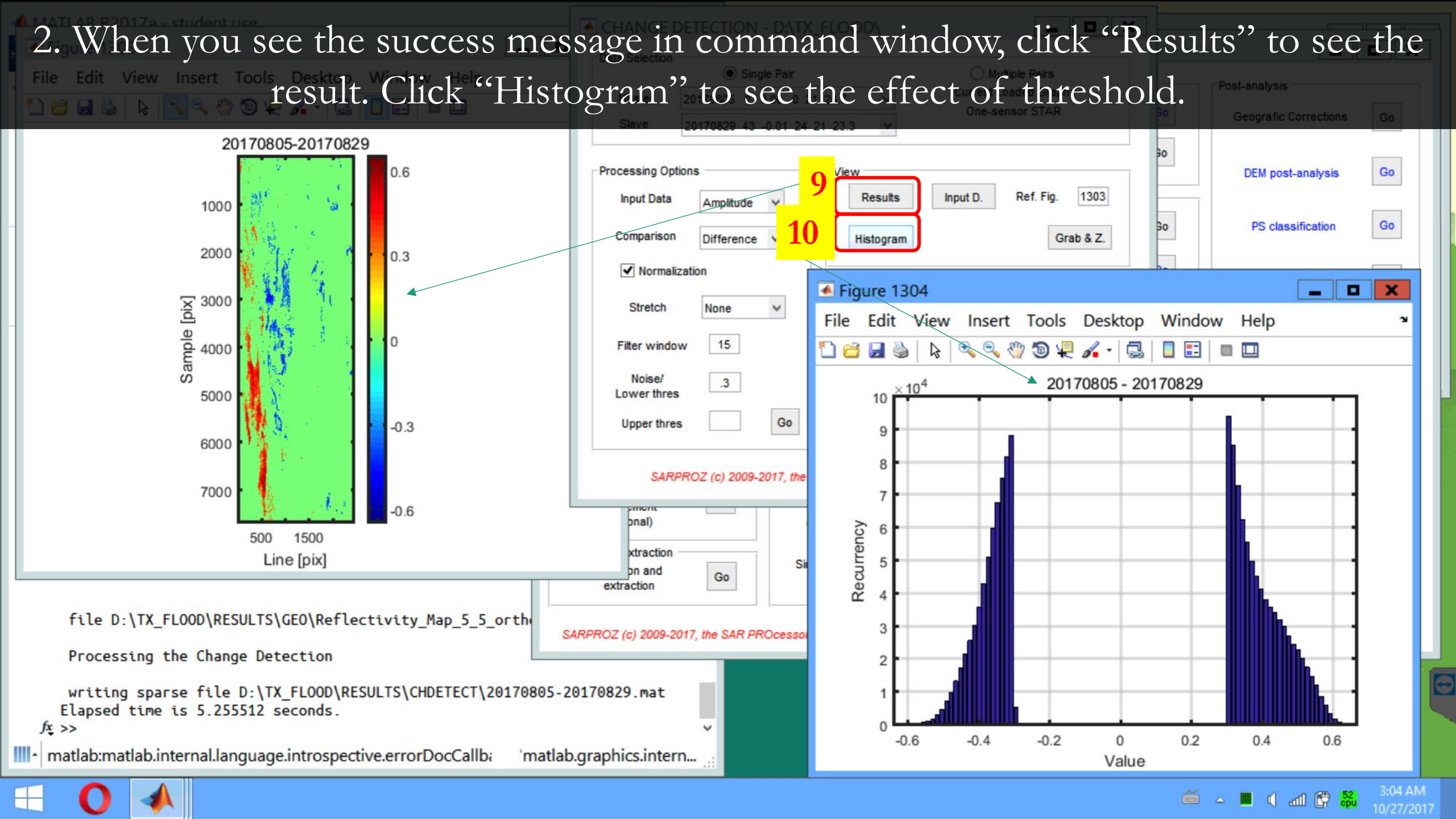


1. Click “Change detection” in “Auxiliary analysis” module. Choose Master and Slave image. Use “Amplitude” as input and “Difference” as comparison. Tick “Normalization”. This will normalize the result to [-1,1]. Choose “None” for Stretch.

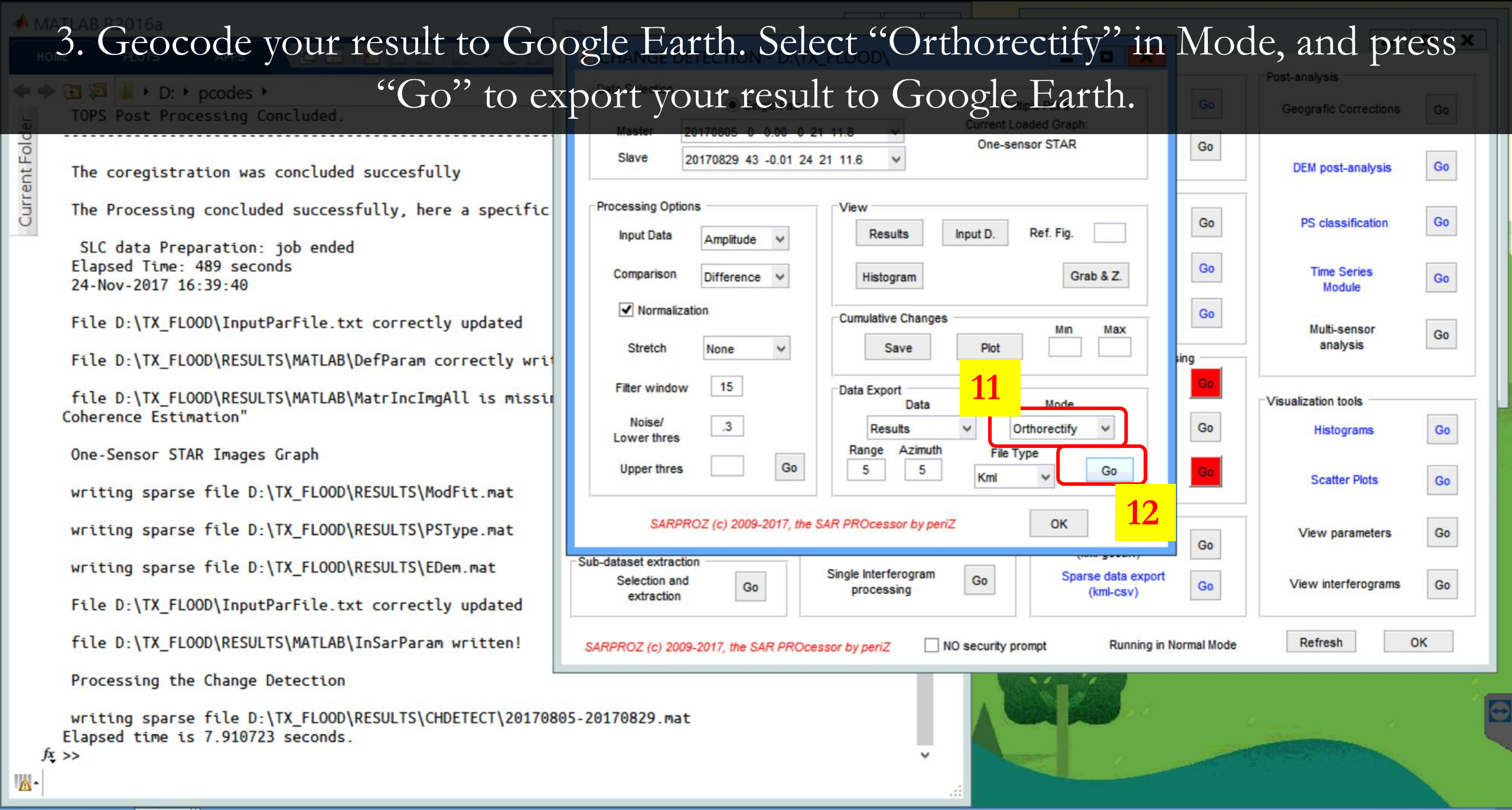


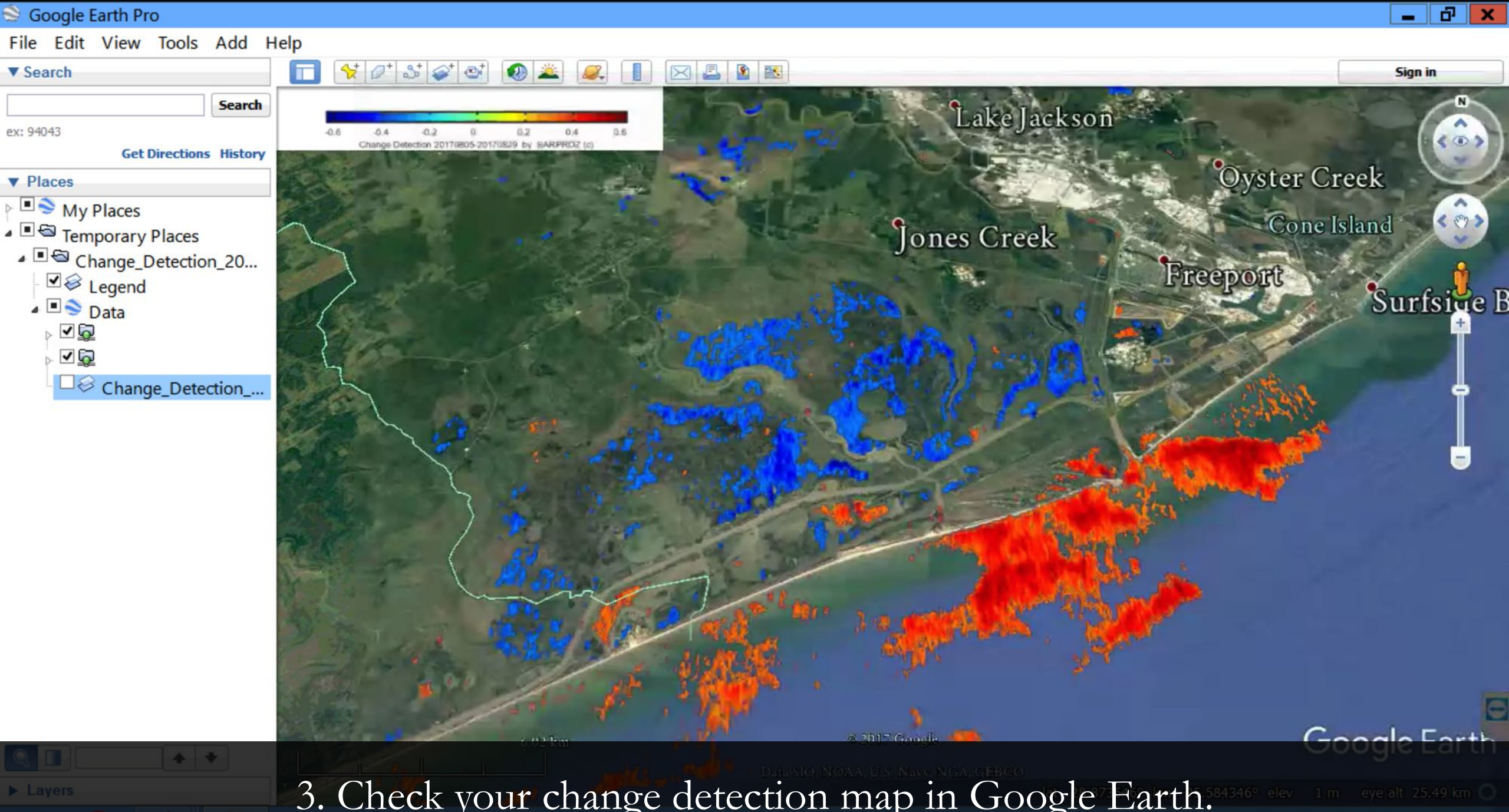
1. (contd.) Put “15” as the filter window size. Input “0.3” as lower noise threshold. This will treat all value below 0.3 to zero. Leave upper threshold as blank. Click “Go” to start the change detection process.

2. When you see the success message in command window, click "Results" to see the result. Click "Histogram" to see the effect of threshold.



3. Geocode your result to Google Earth. Select "Orthorectify" in Mode, and press "Go" to export your result to Google Earth.





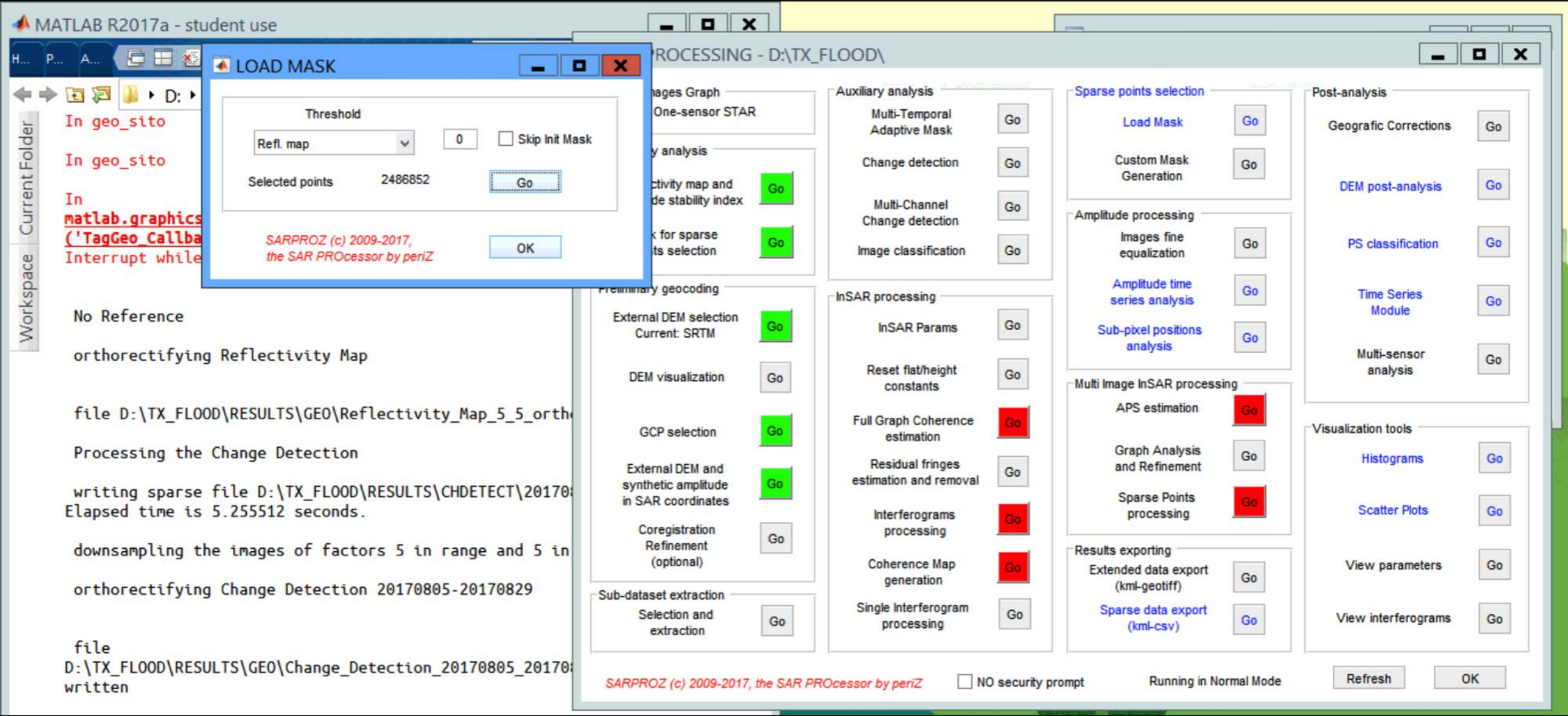
3. Check your change detection map in Google Earth.

Optional Exercise

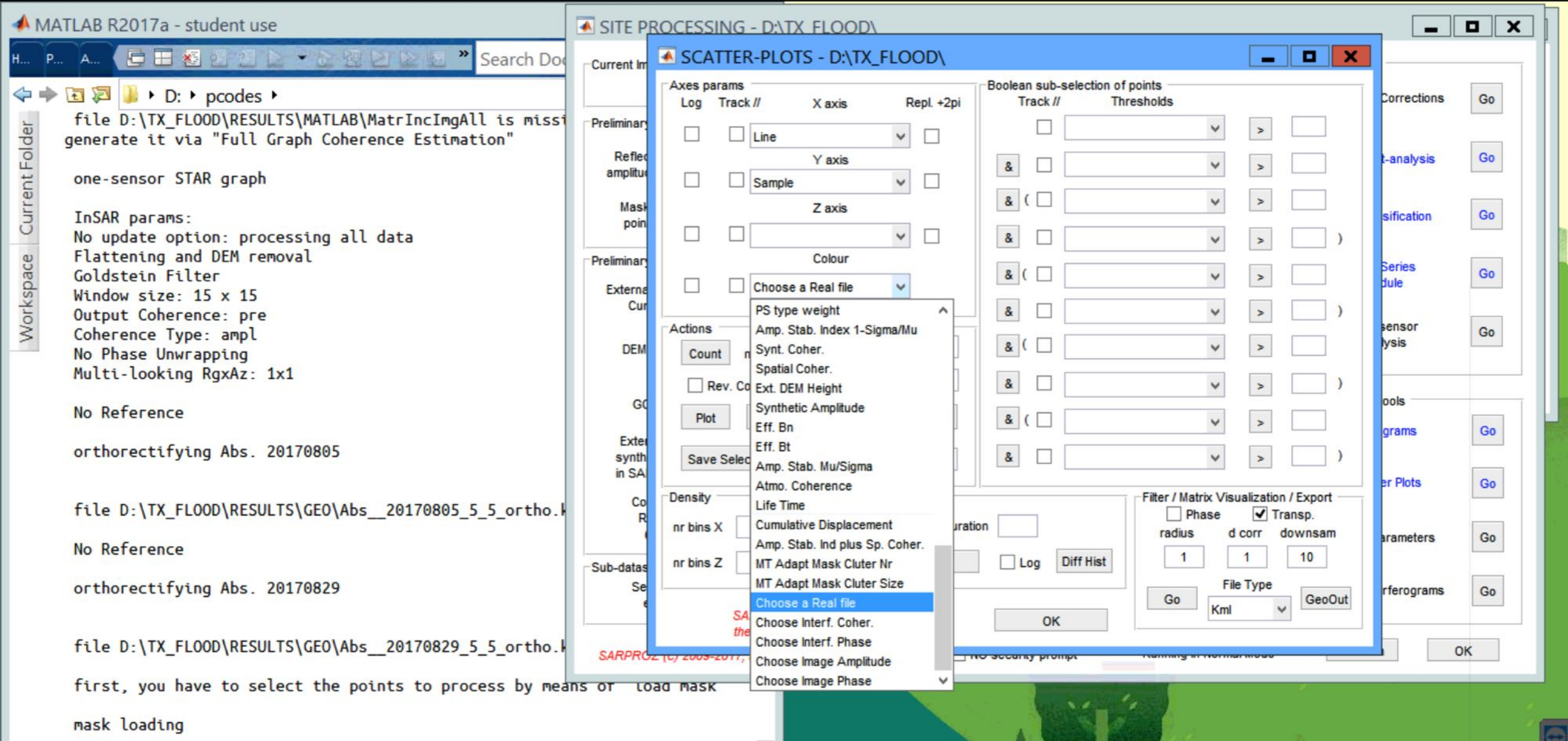
Part 4: Masking out the sea

Mask out the sea

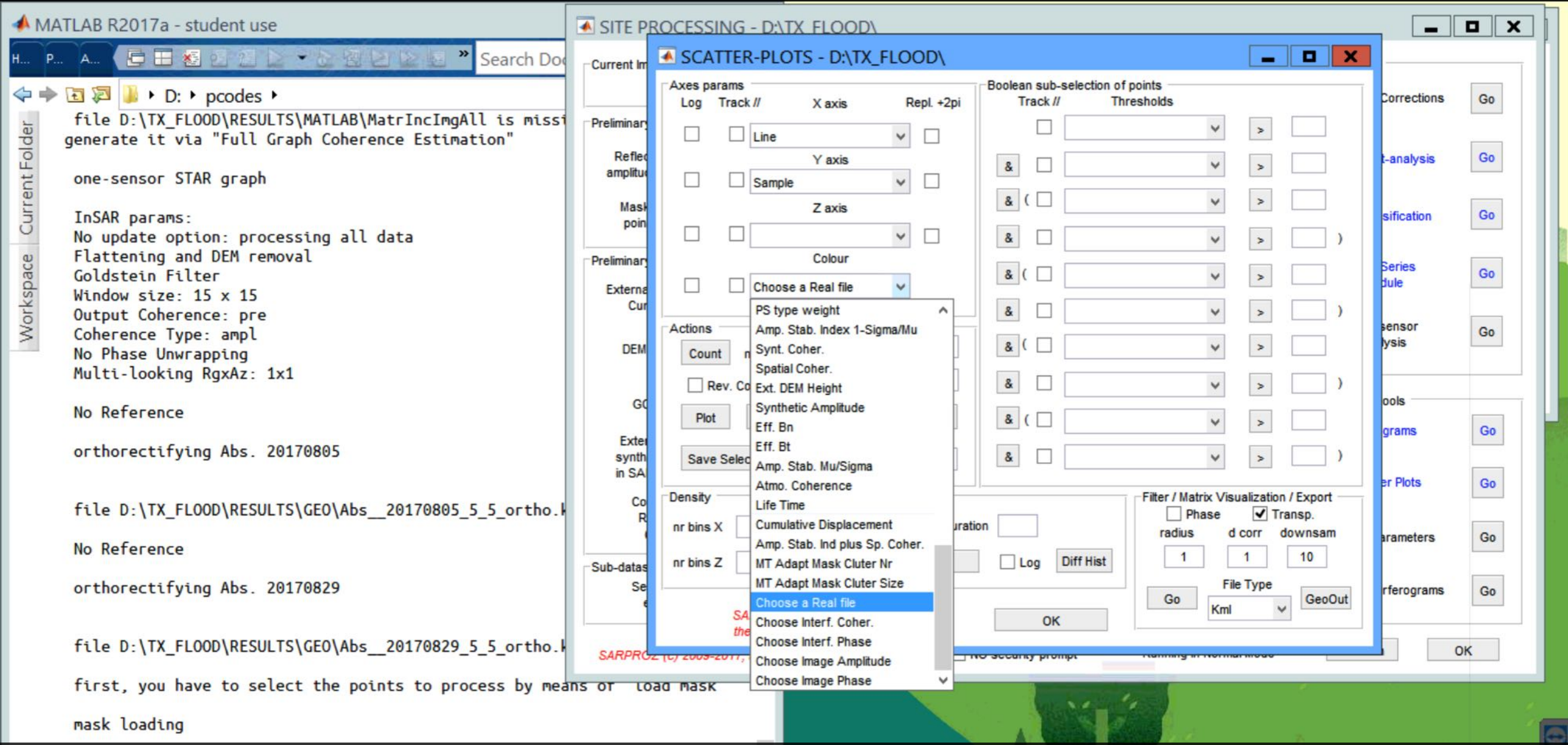
- In previous page, we can see that there are positive and negative value for change detection. Positive value (red) means the slave intensity is greater than master. Negative value (blue) means the slave is smaller than master.
- If we want to look for **flood**, we need only the blue value part where the slave pixel level is significantly smaller than master. (**why?**)
- In this part, we will study how to mask out the red region and keep only the blue region.



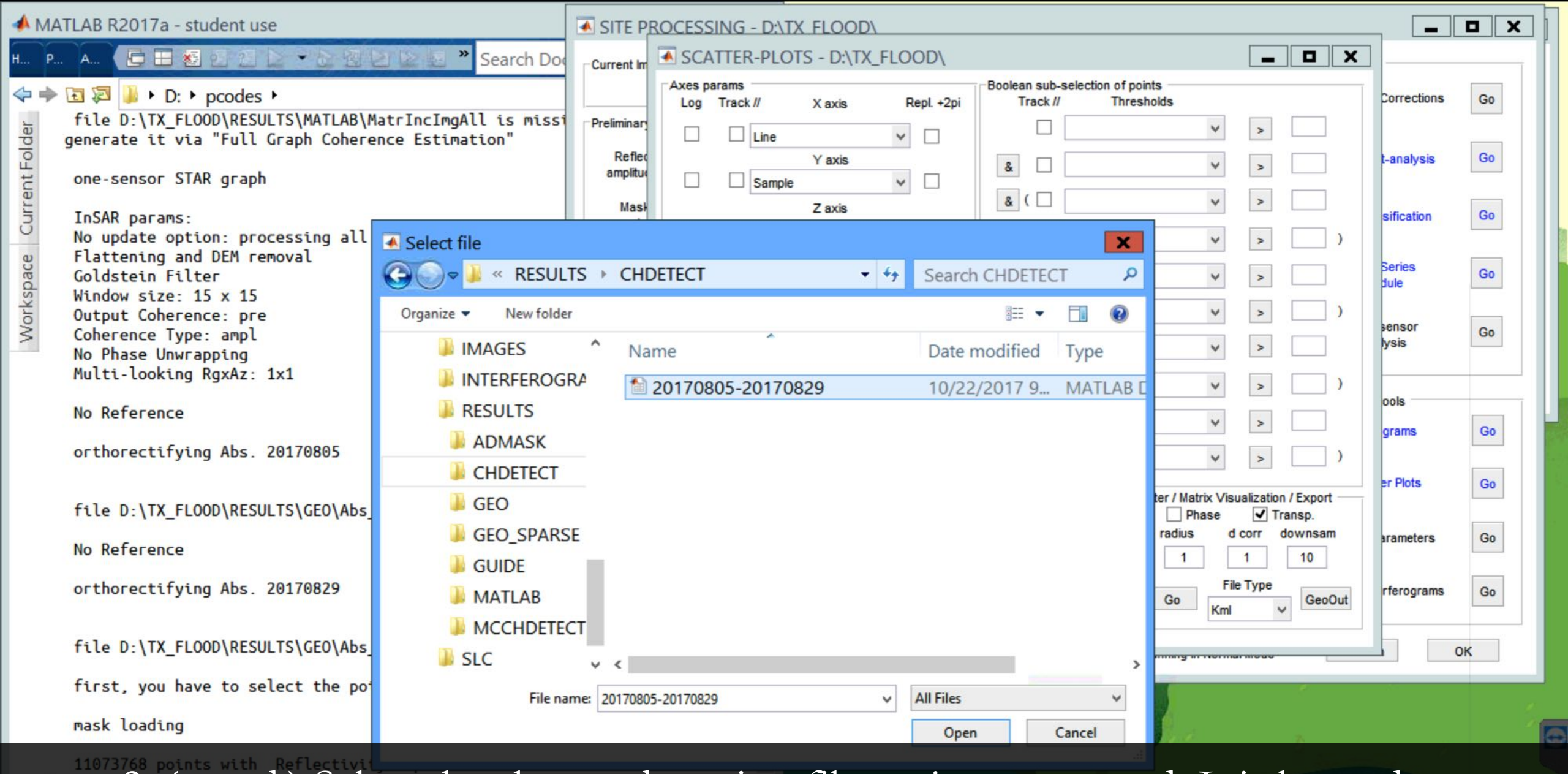
1. Click “Scatter” in “sparse points selection” panel. Select “Refl. map” as the parameter of threshold. Input “0” as press “Go”. You will see a total of around 2.5 million points selected as the points to be processed.



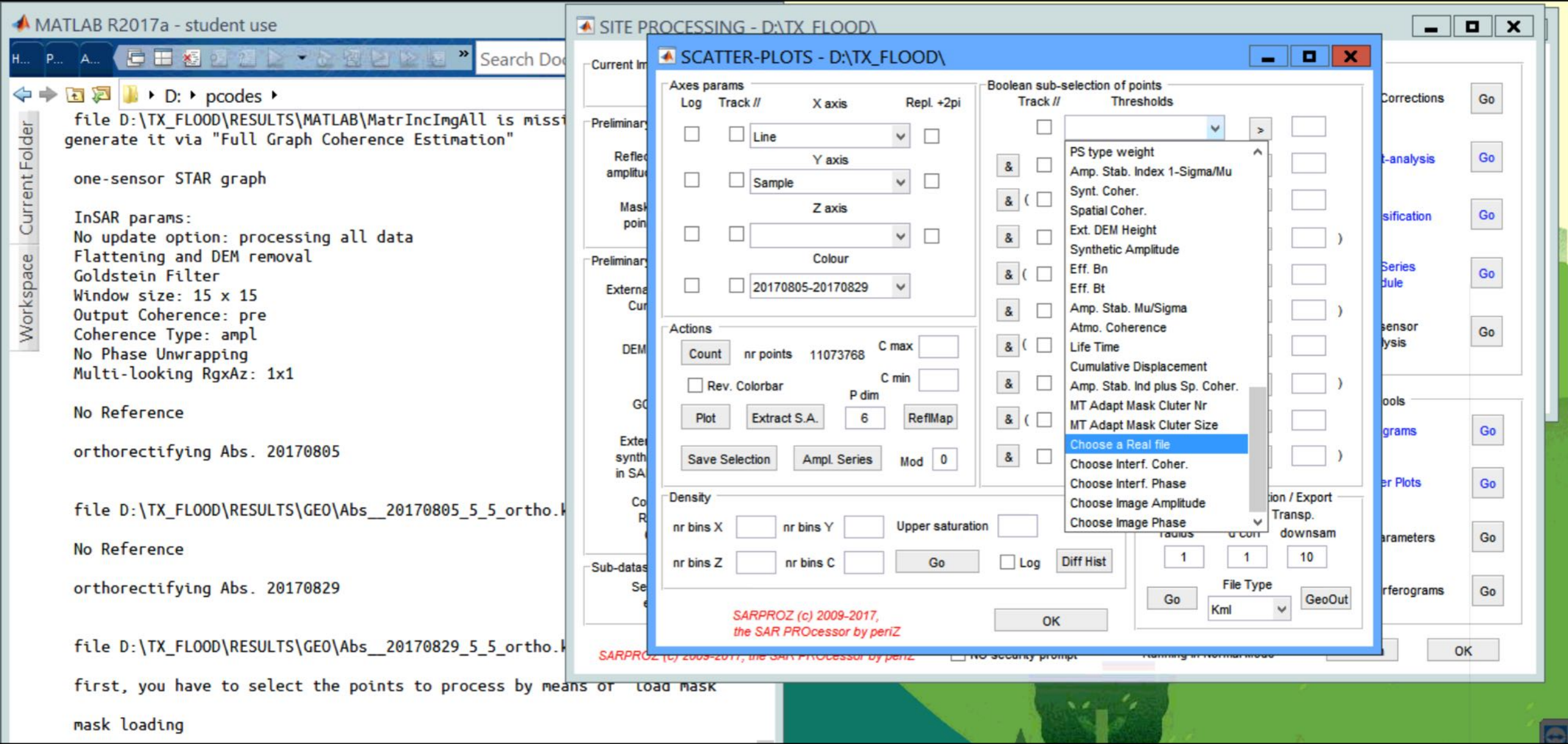
2. Click “Scatter Plots” in “Visualization tools” panel. This is an advanced points selection function. You can select points based on all kinds of conditions you set.



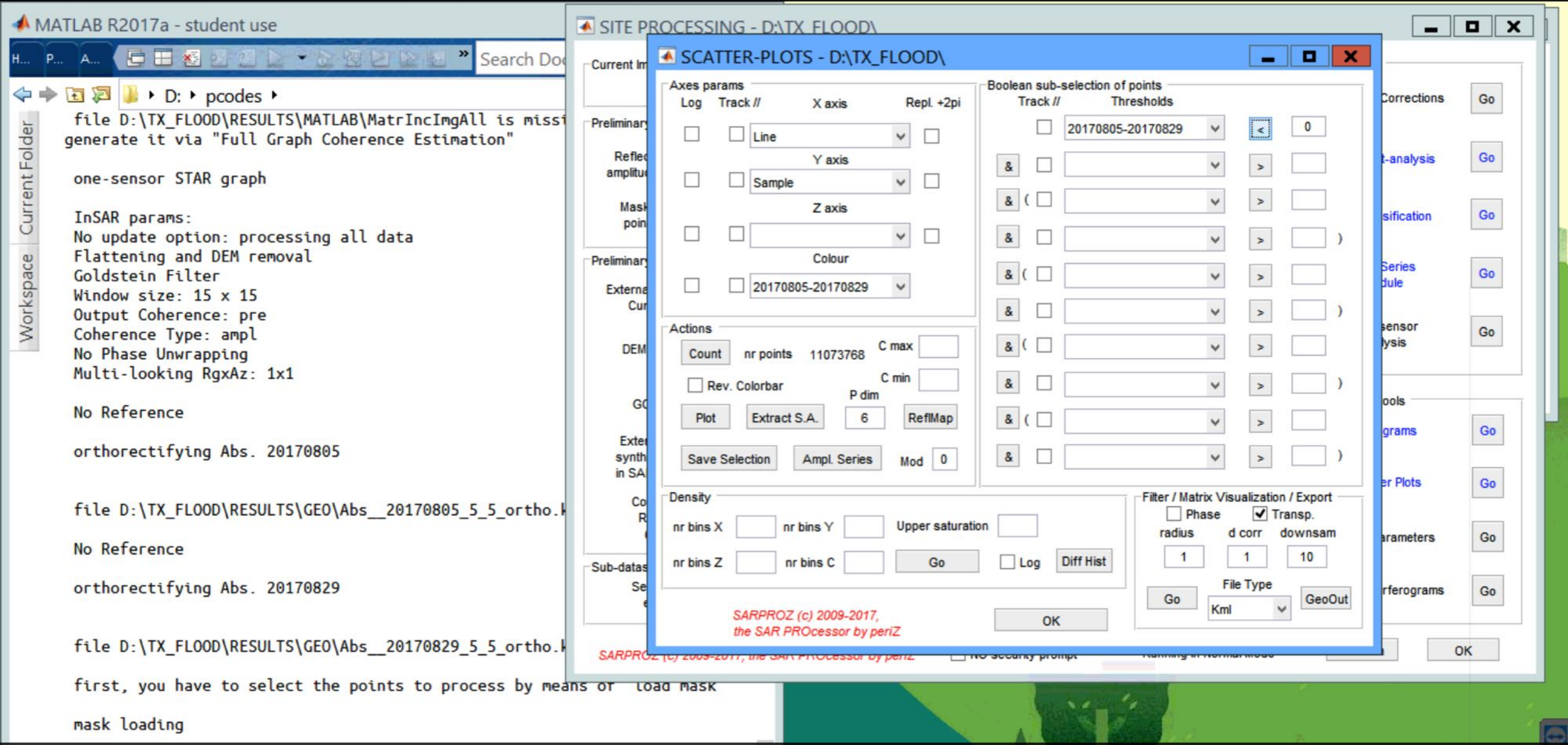
2. (contd.) Choose “Line” as X-axis and “Sample” as Y-axis. We want to display the change detection, so in “Color”, select “Choose a real file”.



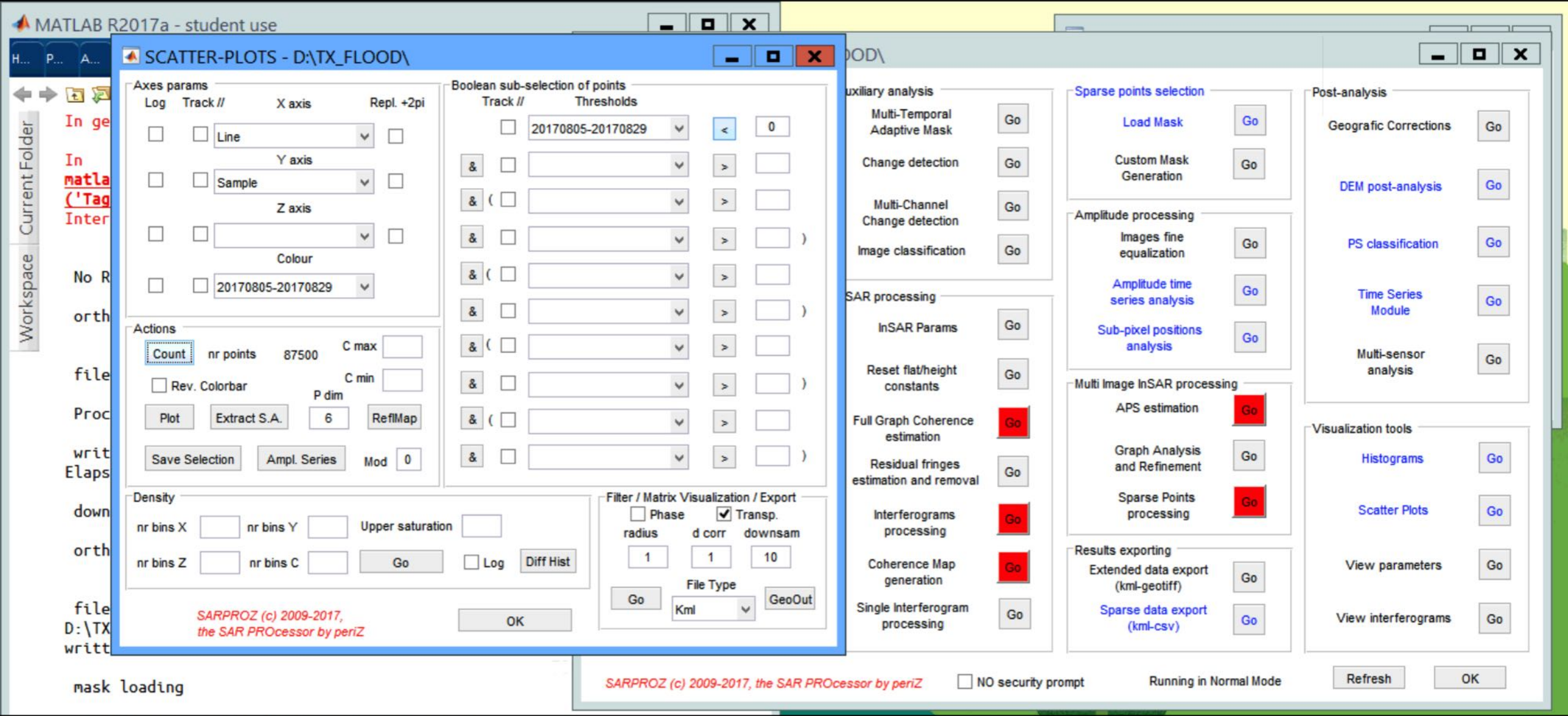
2. (contd.) Select the change detection file we just generated. It is located at "TX_FLOOD\RESULTS\CHDETECT\20170805-20170829".



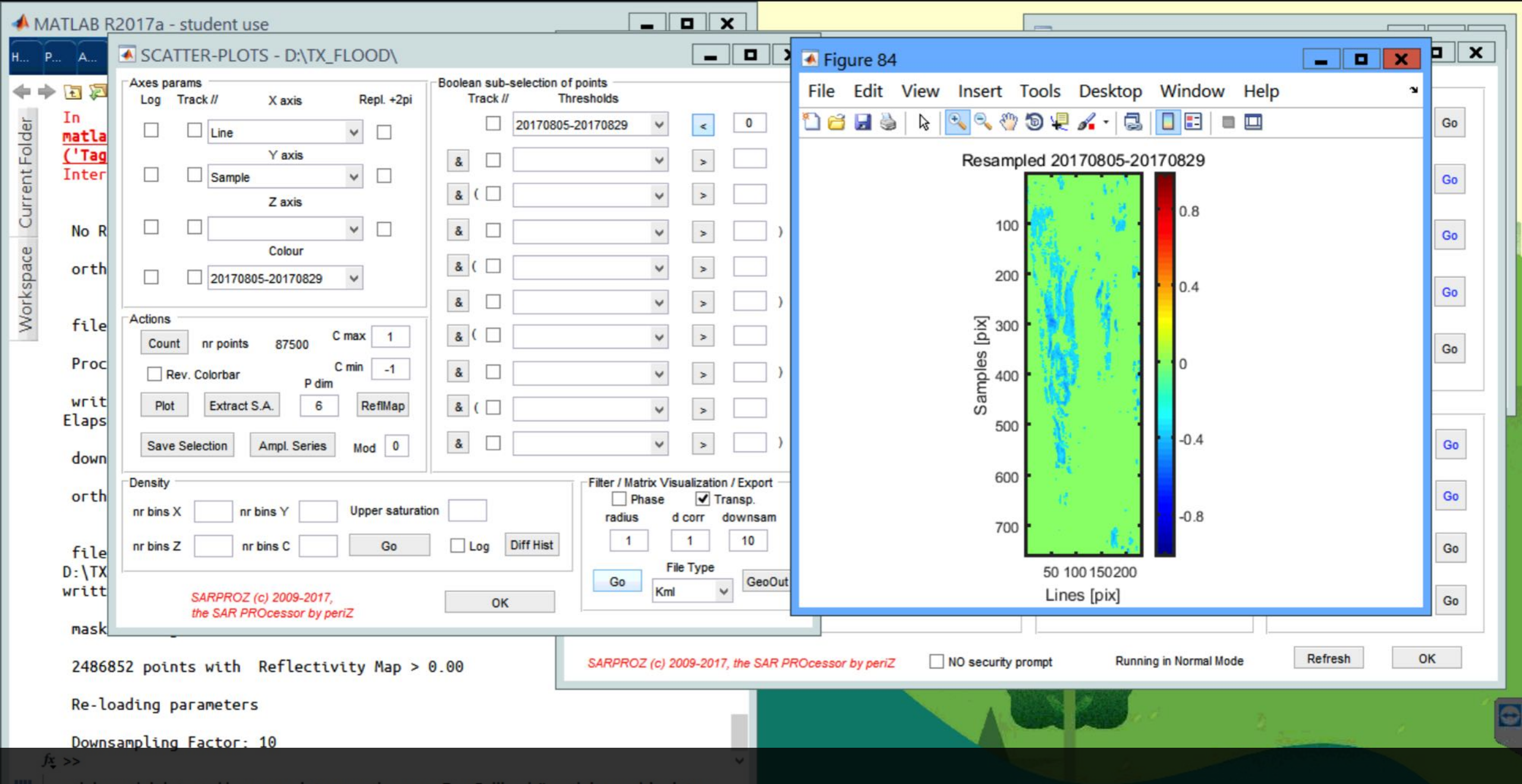
3. As said, we want to filter out all the positive value in change detection map. To do so, in the "Threshold" drop down menu on the right, choose the same file.



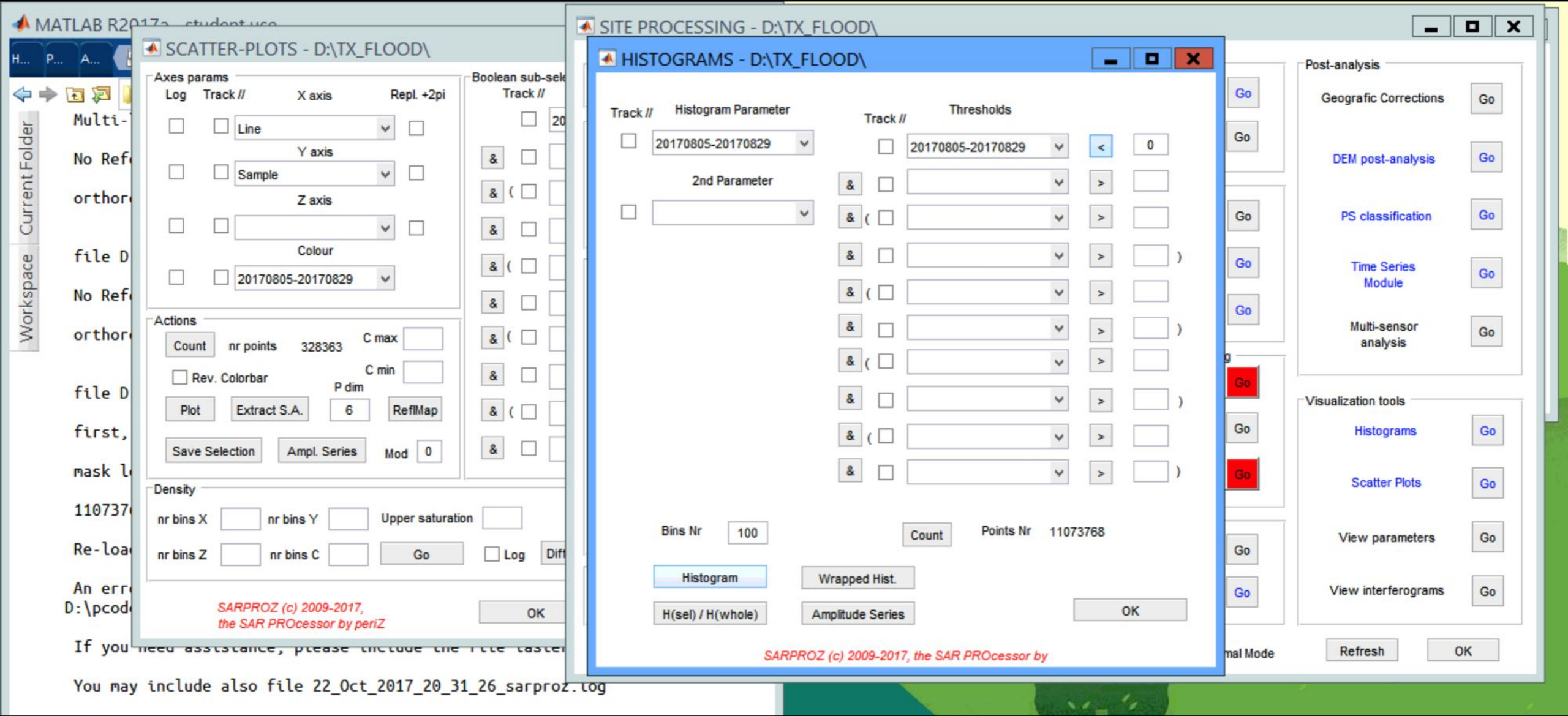
3. (contd.) Click on “>” to change it to “<”. Input “0” to imply we want to keep only those points with value smaller than zero.



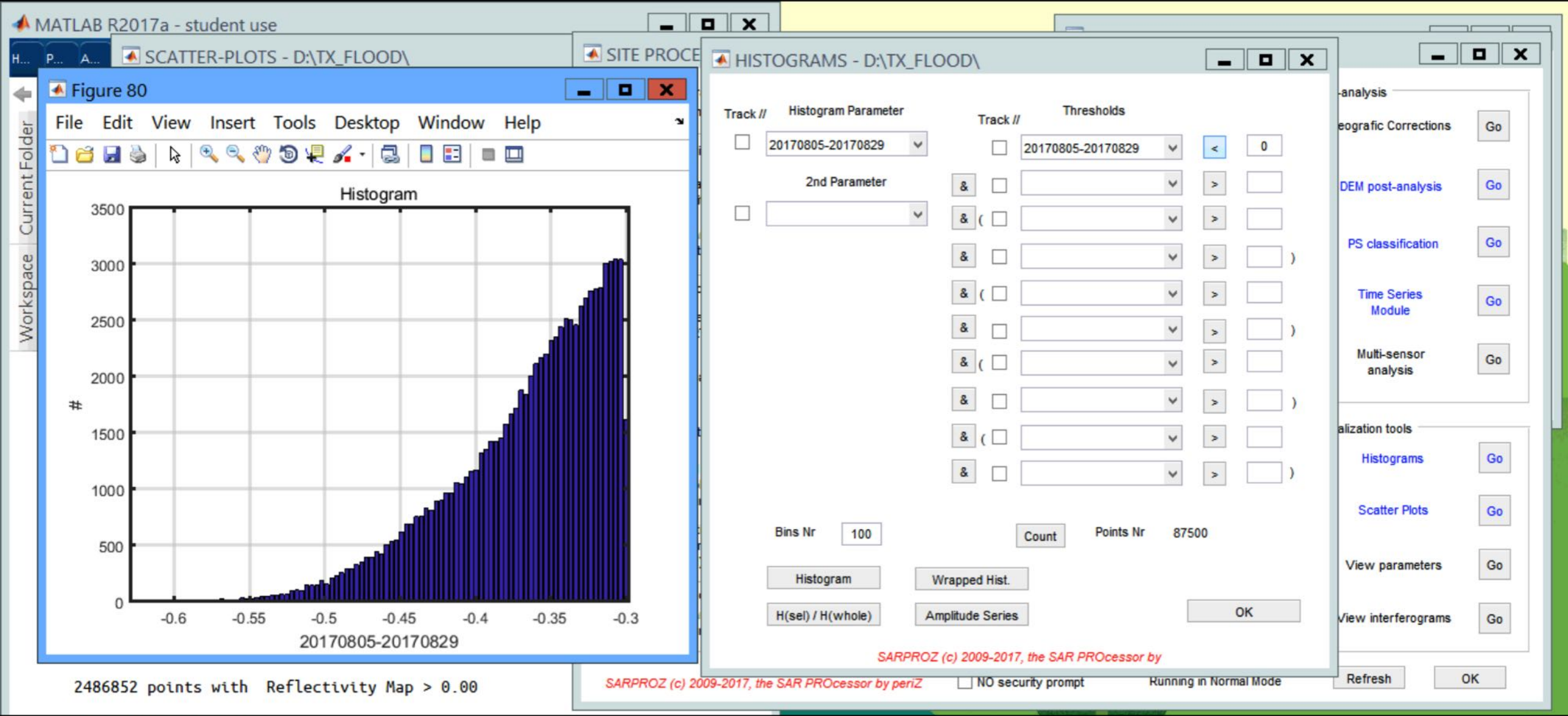
4. Click “Count” in “Actions” panel. This will count the points that satisfy the condition you just set. Input 1 and -1 in C-max and C-min. This will set the colorbar range to [-1,1]. We want to keep consistency with previous result.



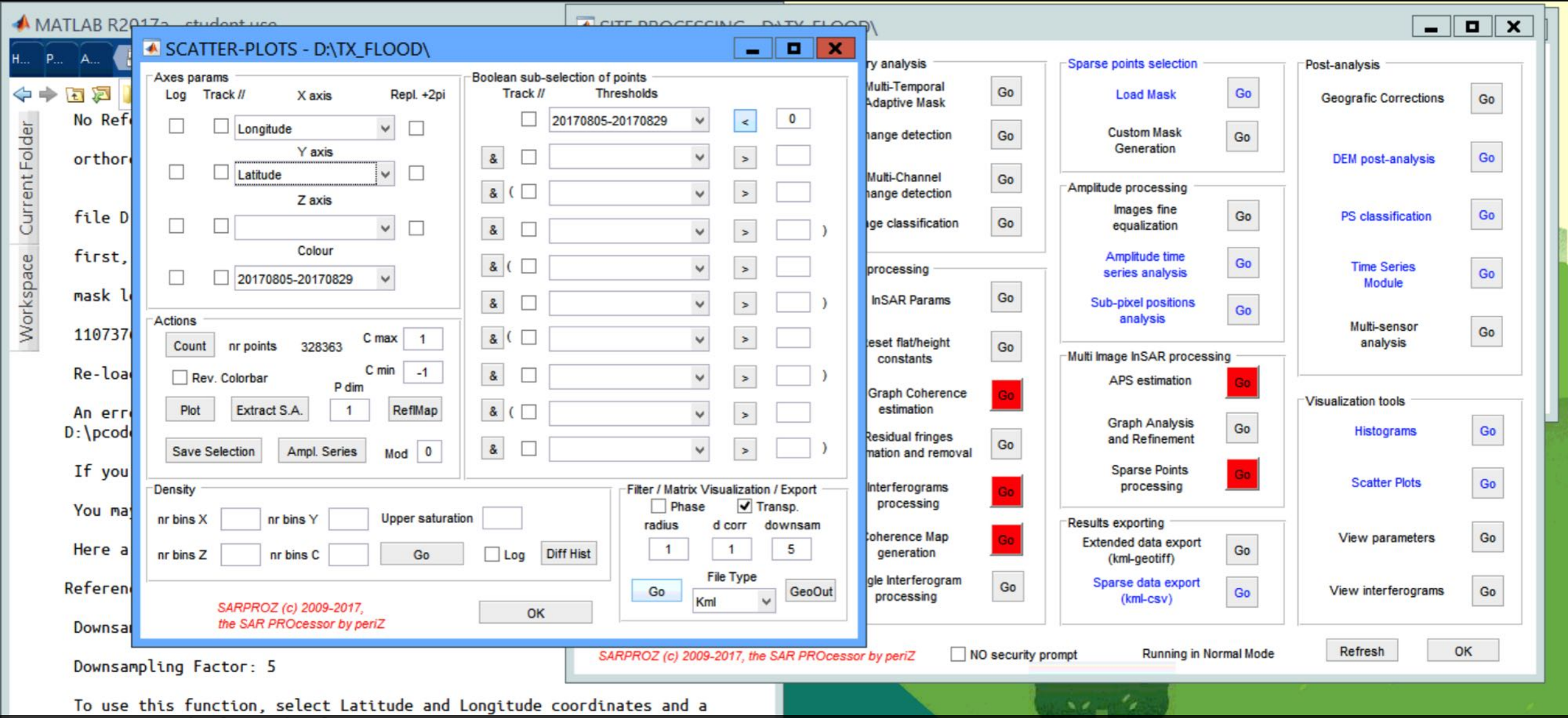
5. In the lower right corner, click “Go” to view your result after filtering.



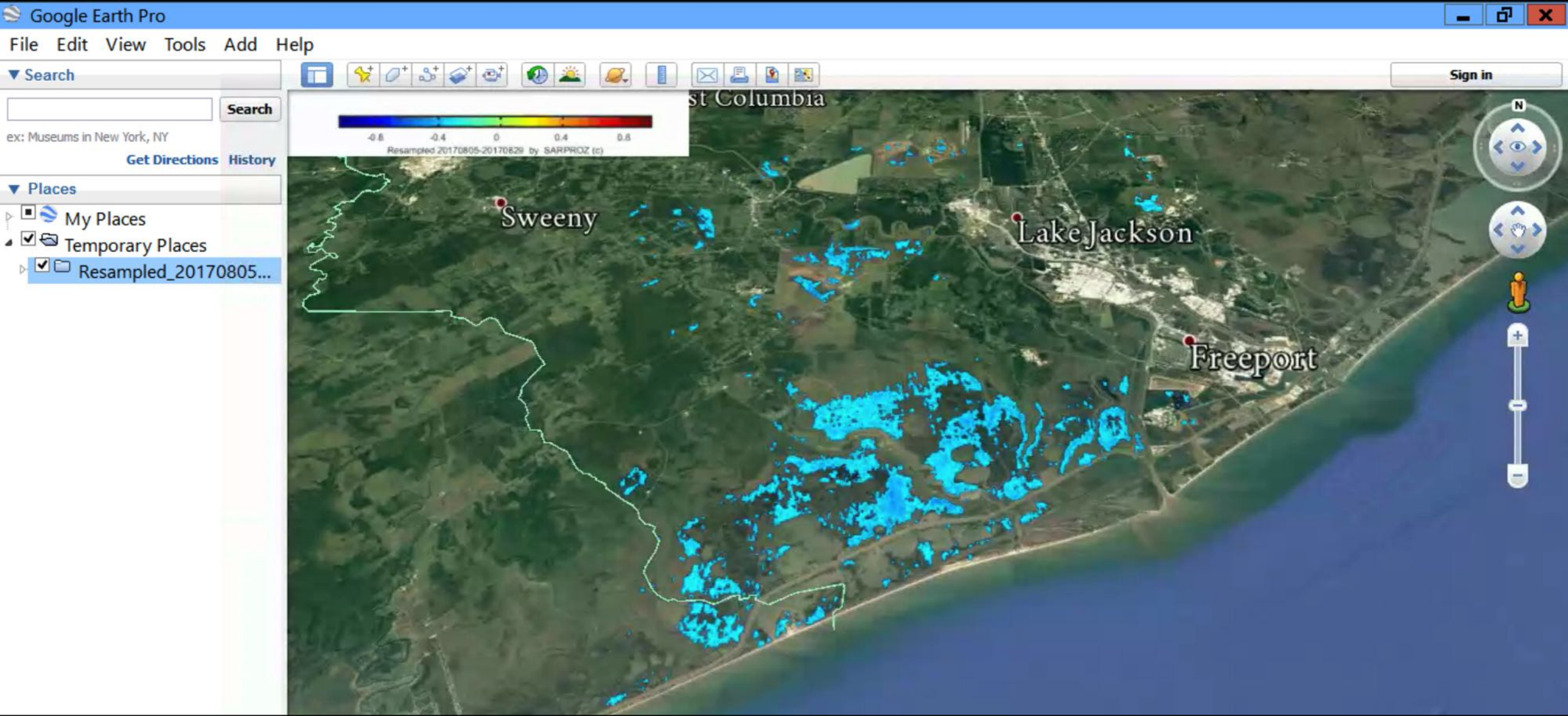
6. Another way to check your result is by **histogram**. Click "Histogram" in "Visualization tools" panel to use this function. Use the exact same steps to choose points with negative value in change detection result.



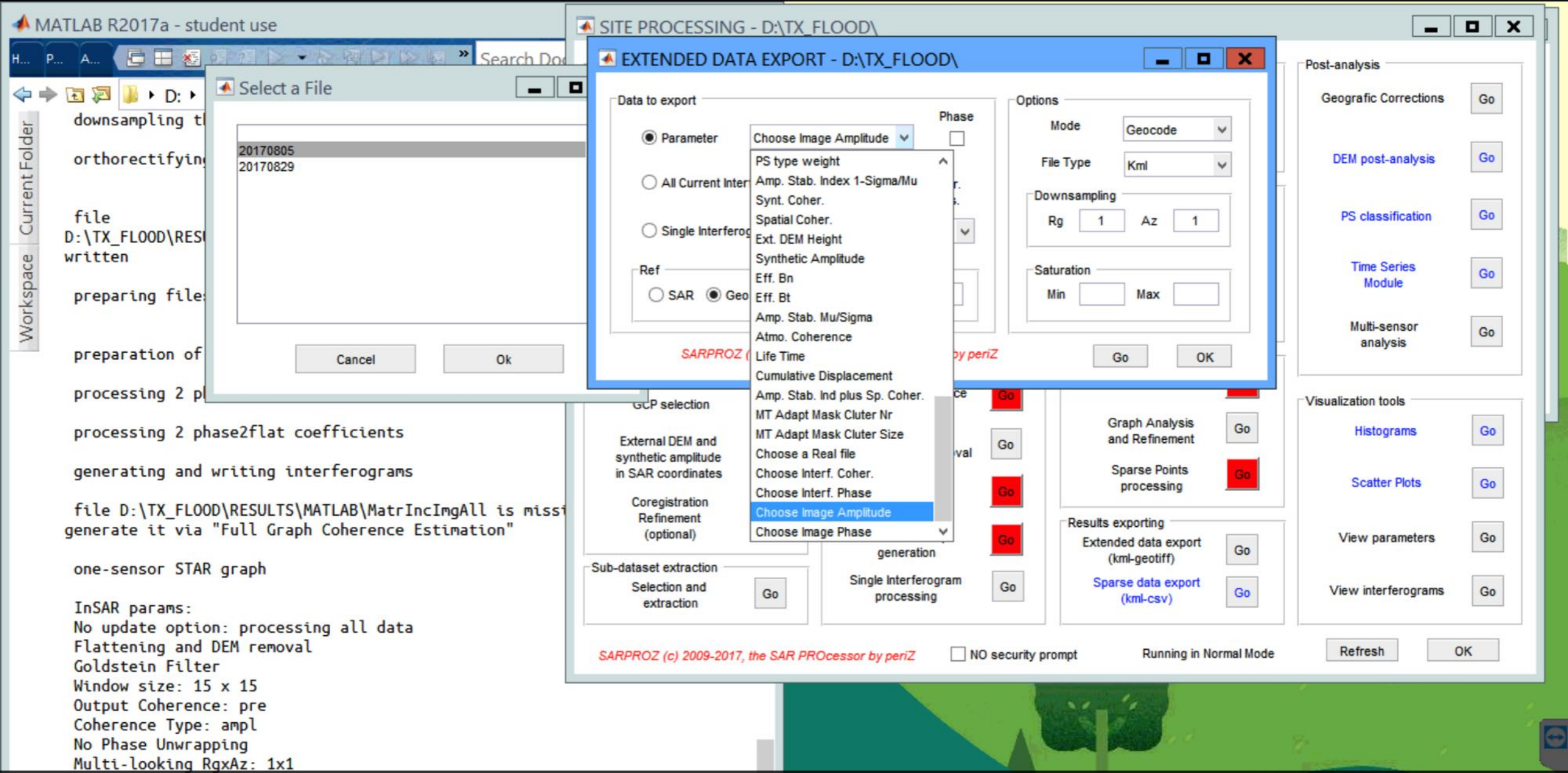
7. Click “Count” to count the points after you set the condition. Click “Histogram” to display the histogram. We could clearly see that all the points with positive value in change detection result is filtered out.



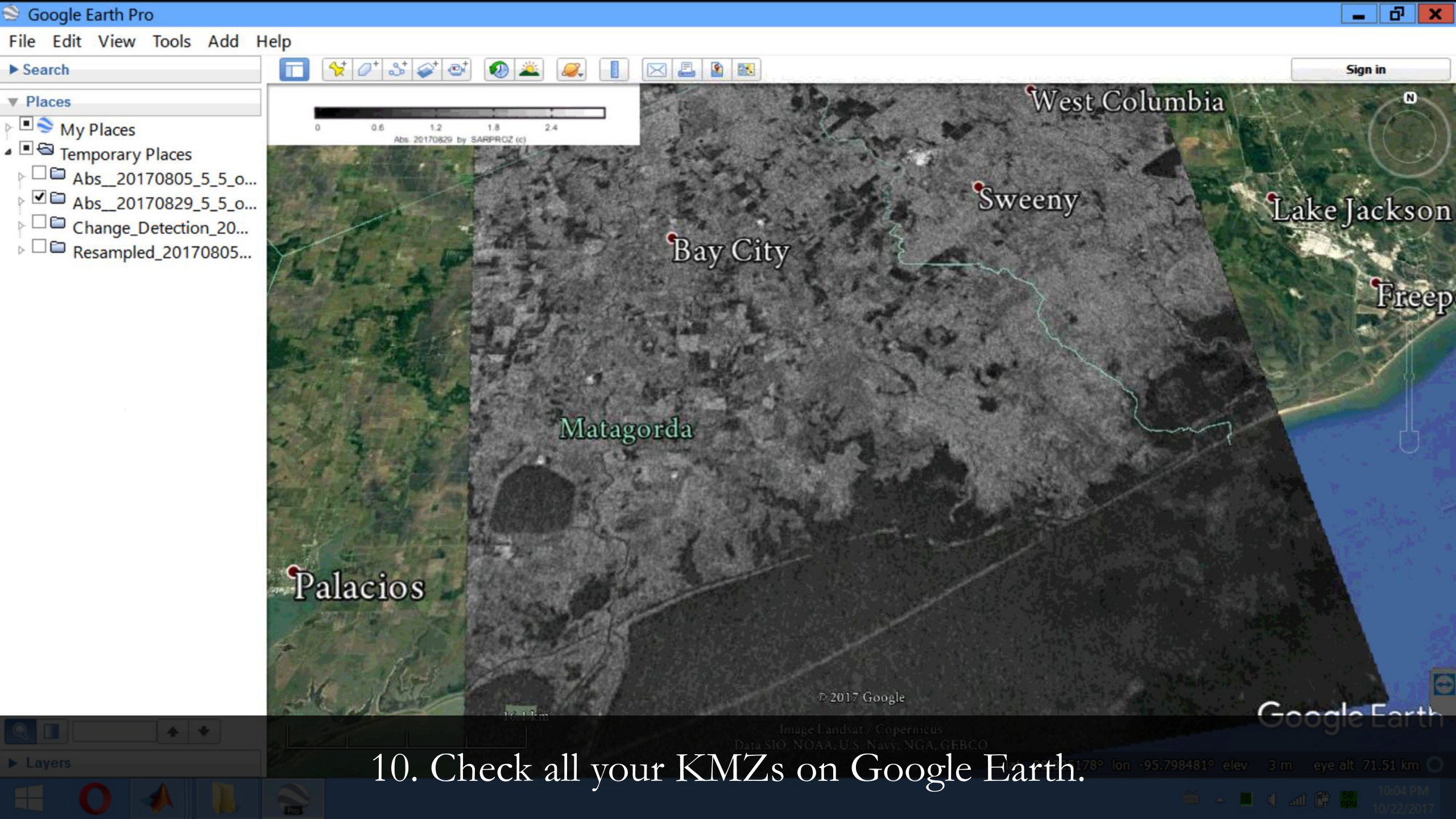
8. At last, to geocode the new result to Google Earth, change X-axis to “Longitude” and Y axis to “Latitude”. Choose 5 as downsample factor. Click “GeoOut” to geocode.



9. If Google Earth does not start automatically, you can always find all your products in ""TX_FLOOD\RESULTS\GEO" folder.



You can also geocode master and slave image separately. Select “Choose Image Amplitude” when selecting geocoding parameter.



10. Check all your KMZs on Google Earth.

Bye