



# Pre-processing and multi-temporal analysis of SAR time series

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培训时间: 2019年11月18日-23日 主办方: 重庆大学



## Part 1

# Multitemporal Analysis of SAR Backscatter Intensity



# Objectives



- Familiarizing with SNAP toolbox
- Familiarizing with Sentinel-1 GRD products
- Calculation of backscatter intensity from Sentinel-1 detected products
- Analysis of temporal backscatter signatures for various land cover types
- Change detection over AOI (Beijing Daxing International Airport)



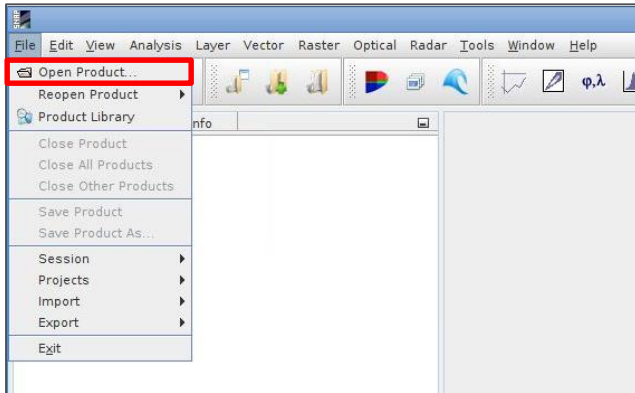
Input data: time series of Sentinel-1 GRDH images over China

*S1A\_IW\_GRDH\_1SDV\_20151003T222044\_20151003T222111\_007994\_00B2F6\_9374*  
*S1A\_IW\_GRDH\_1SDV\_20160611T222046\_20160611T222112\_011669\_011DDC\_7FB0*  
*S1B\_IW\_GRDH\_1SDV\_20171115T222014\_20171115T222041\_008298\_00EAE8\_2415*  
*S1B\_IW\_GRDH\_1SDV\_20181110T222021\_20181110T222048\_013548\_019131\_A556*  
*S1B\_IW\_GRDH\_1SDV\_20190930T222028\_20190930T222054\_018273\_022698\_C498*

Output:

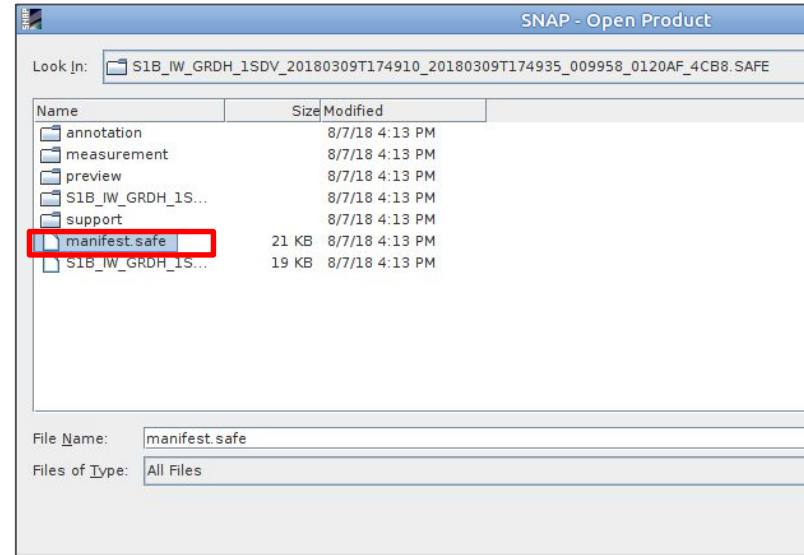
- temporal backscatter signatures for various land cover types
- change detection

## 1. Opening the S1 data



S1B\_IW\_GRDH\_1SDV\_20190219T055747\_20190219T055812\_015011\_01C0C5\_16E0.zip  
S1B\_IW\_GRDH\_1SDV\_20190315T055747\_20190315T055812\_015361\_01CC2F\_2DE0.zip  
S1B\_IW\_GRDH\_1SDV\_20190420T055748\_20190420T055813\_015886\_01DD7D\_B255.zip  
S1B\_IW\_GRDH\_1SDV\_20190514T055749\_20190514T055814\_016236\_01E8EA\_C0BC.zip  
S1B\_IW\_GRDH\_1SDV\_20190713T055752\_20190713T055817\_017111\_020314\_33F3.zip  
S1B\_IW\_GRDH\_1SDV\_20190818T055755\_20190818T055820\_017636\_0212DC\_C2D4.zip

## For unzipped products



- Creating a subset of S1 GRDH images

  - Spatial subset depending on the AOI*

- Updating orbits

- Radiometric calibration

  - Conversion of image intensity to sigma0 providing the radar backscatter*

- Terrain correction

  - Compensate for geometric distortions caused by topographical variations of a scene and the tilt of satellite sensor*

- Creating a multitemporal stack

  - Collocation spatially overlapping products (based on geolocation)*

- Speckle filtering

  - Filtering the inherent salt and pepper like texturing called speckles*

- Linear to dB conversion

  - Compensate for very high dynamic range in visualisation*

- Stack statistics and analysis of temporal backscatter signatures

- Creating a subset of S1 GRDH images

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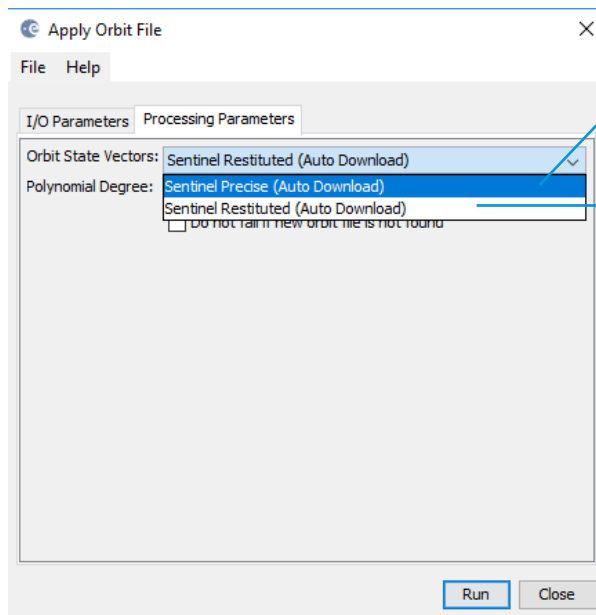
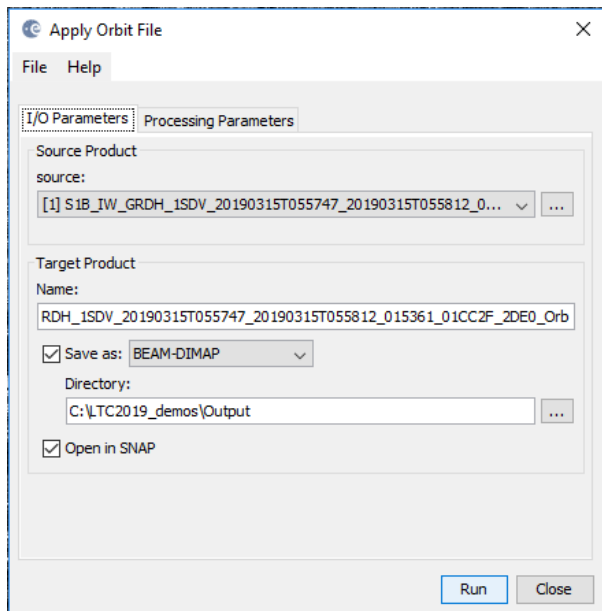
- Linear to dB conversion

  - Compensate for very high dynamic range in visualisation*

- Stack statistics and analysis of temporal backscatter signatures

## Radar / Apply orbit file

The orbit file provides accurate satellite position and velocity information. Based on this information, the orbit state vectors in the abstract metadata of the product are updated.



POEORB - few weeks after acq.

RESORB - within few hours



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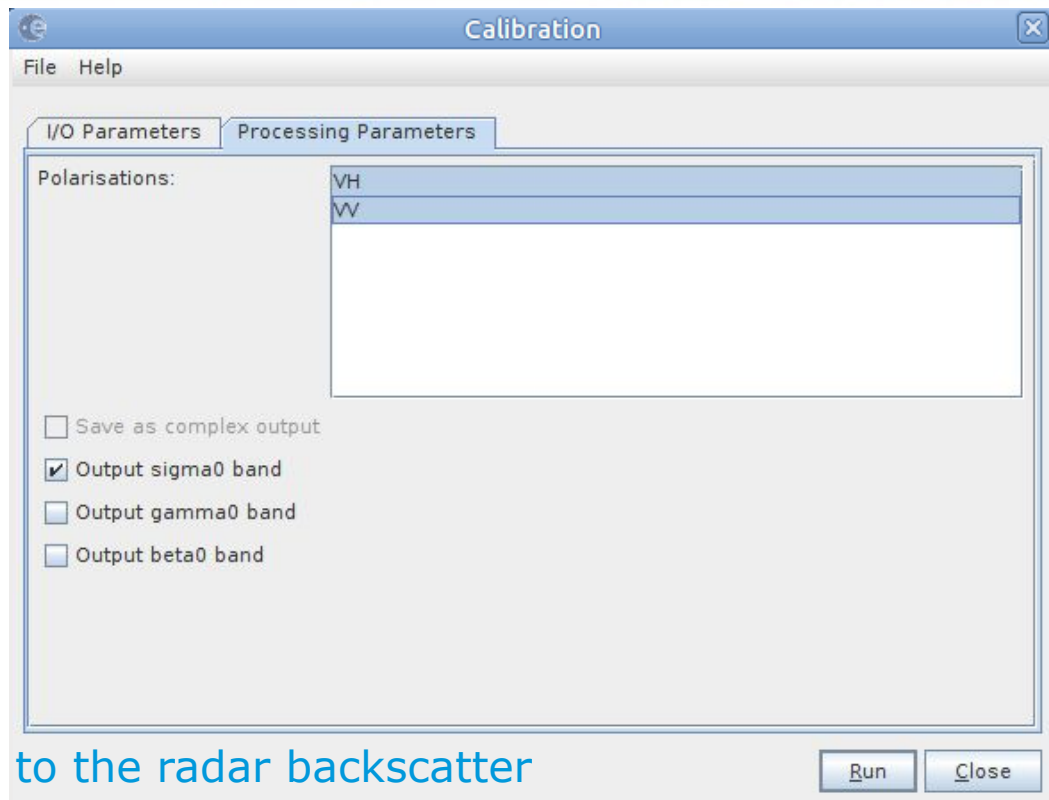
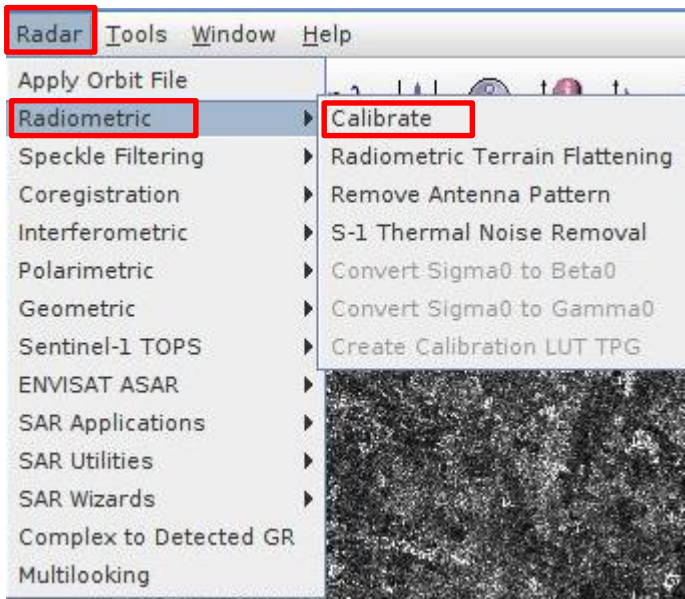
- Stack statistics and analysis of temporal backscatter signatures

From image pixel values or digital numbers (DNs) we can derive:

**Beta Naught** – radar brightness coefficient, reflectivity per unit area in slant range which is dimensionless

**Sigma Naught** – power returned to the antenna from the ground (distributed scatterer) in dB. A number comparing the strength of the signal to that expected from an area of one square meter. It is defined with respect to the nominal horizontal plane and is varying with incidence angle, wavelength, polarisation and scattering surface itself

## Radar/Radiometric/Calibrate



Pixel values can be directly related to the radar backscatter

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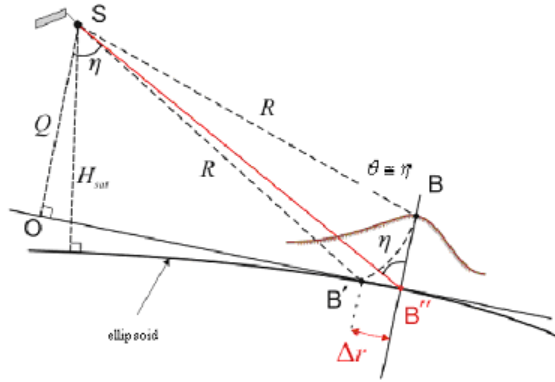
- Speckle filtering

  - Filtering the inherent salt and pepper like texturing called speckles*

- Linear to dB conversion

  - Compensate for very high dynamic range in visualisation*

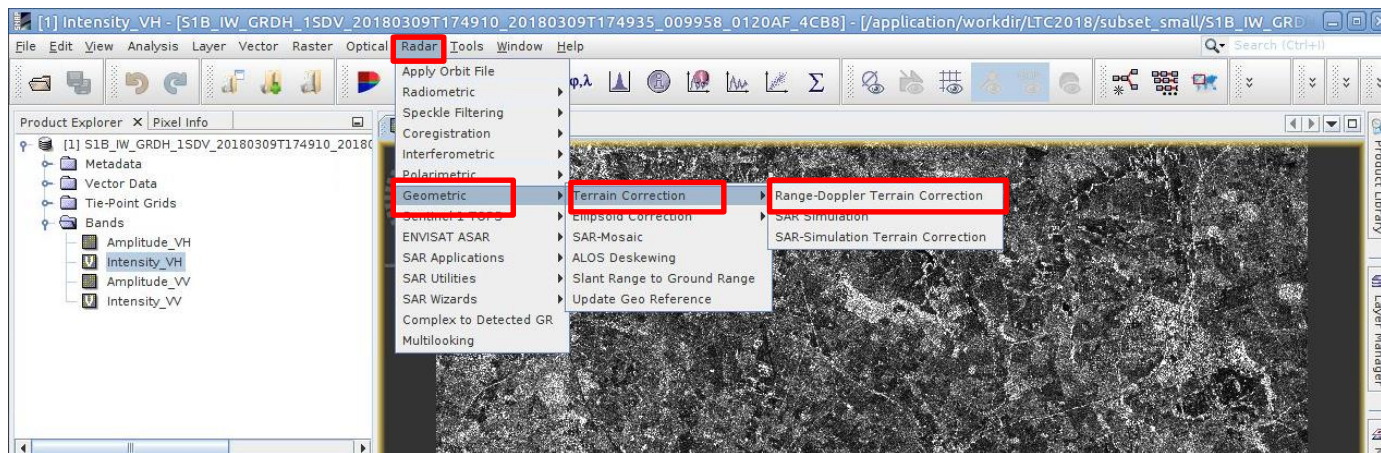
- Stack statistics and analysis of temporal backscatter signatures



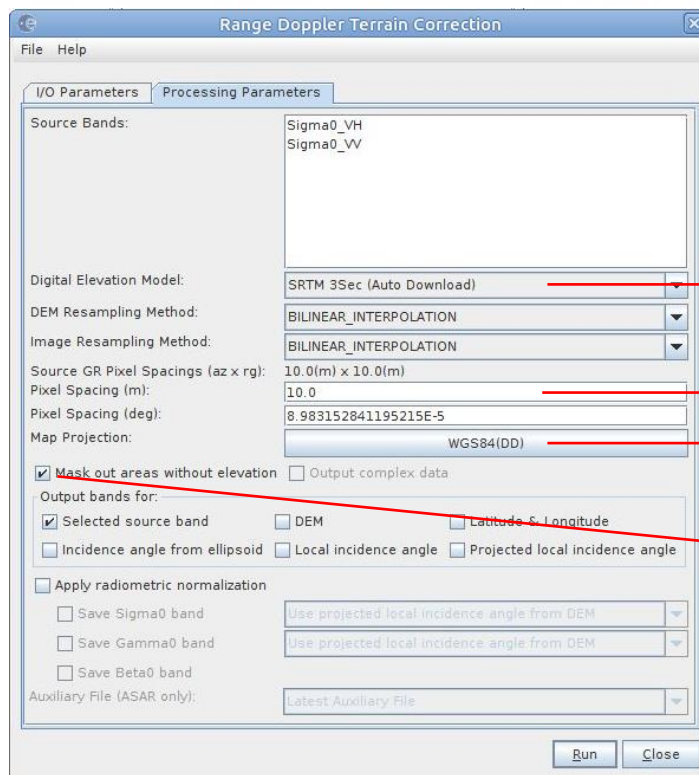
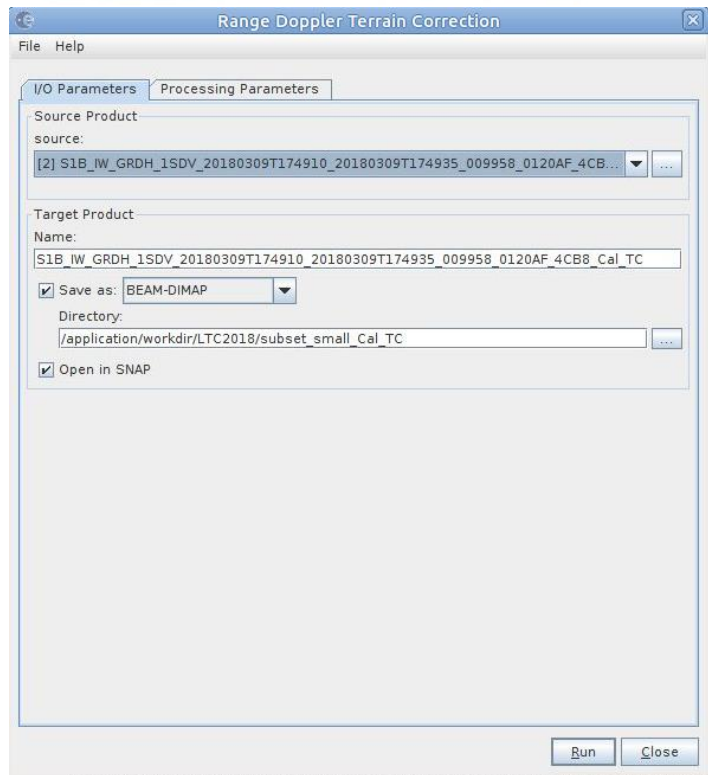
Point **B** with elevation **h** above the ellipsoid is imaged at position **B'** in SAR image, though its real position is **B''**. The offset  $\Delta r$  between **B'** and **B''** exhibits the effect of topographic distortions

*Terrain Correction allows geometric overlays of data from different sensors and/or geometries.*

## *Radar / Geometric / Terrain Correction / Range Doppler Terrain Correction*



# Terrain correction & Geocoding



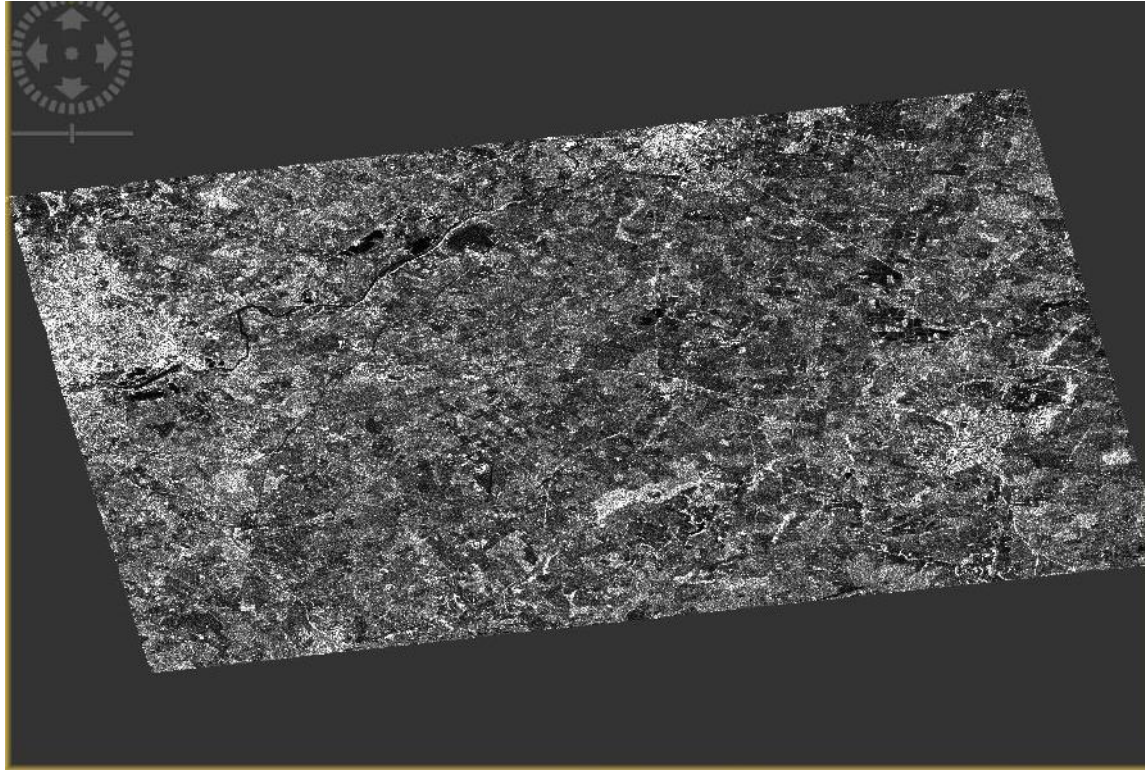
DEM selection

Pixel spacing

Map projection

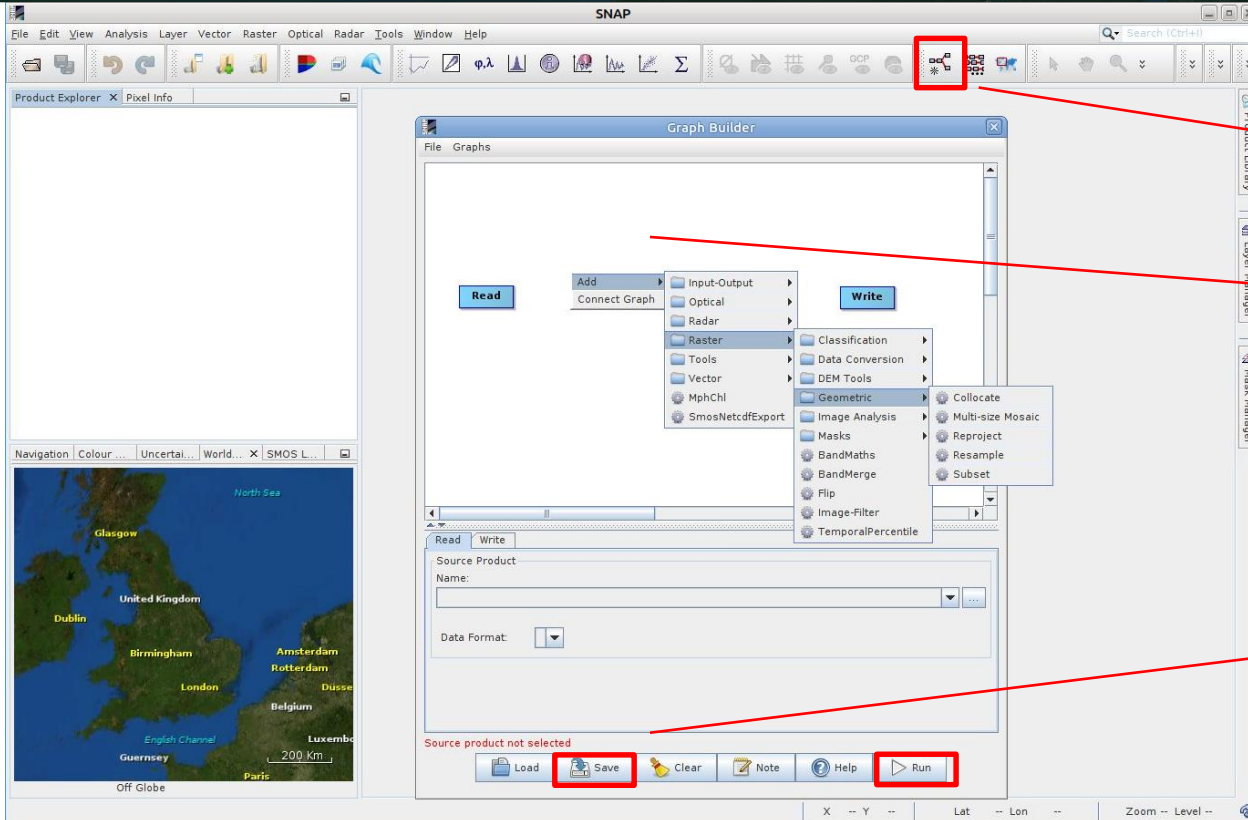
Masking areas without elevation







# Automatic Processing with Graph



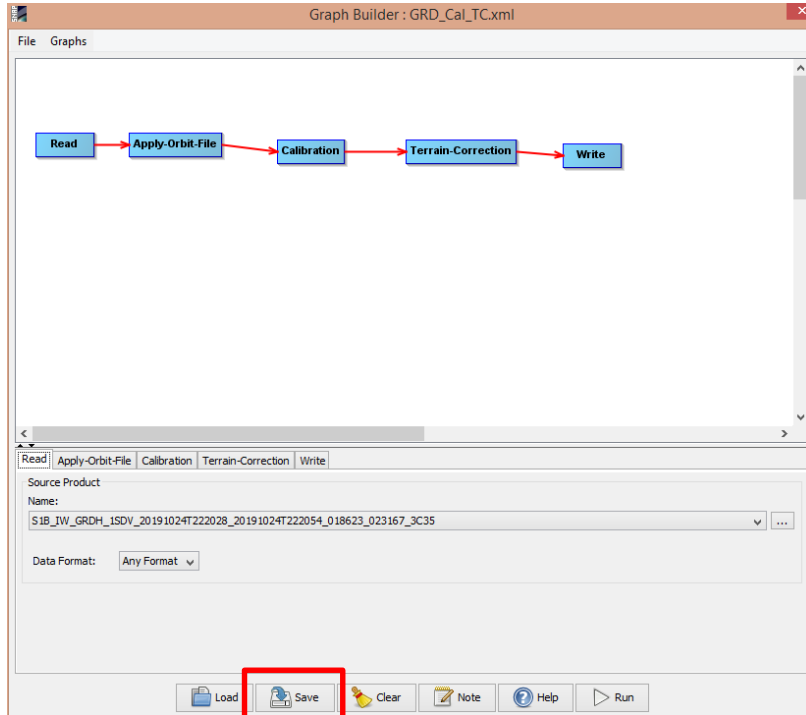
Graph Builder

Inserting blocks with particular processing operators (right mouse button)

Save the graph and/or Run



# Automatic Processing with Graph – Calibration Terrain Correction



*Apply Orbits: Sentinel Precise  
Calibration: Output Sigma0  
Terrain Correction: pixel spacing 10m*

The same settings like  
in manual processing

*save as GRD\_Cal\_TC.xml*



# Batch processing



Product Explorer X Pixel Info

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Batch Processing

File Graphs

I/O Parameters

File Name	Type	Acquisition	Track	Orbit

0 Products

Target Folder

Save as: BEAM-DIMAP

Directory: /application/pi/Desktop/subset

Skip existing target files  Keep source product name

Load Graph Run Close Help

Batch processing tool

Adding data products

Loading the graph



# Batch processing



File Graphs

I/O Parameters Apply-Orbit-File Calibration Terrain-Correction Write

File Name	Type	Acquisition	Track	Orbit
Subset_S1A_IW_GRDH_1SD...	GRD	03Oct2015	47	7994
Subset_S1A_IW_GRDH_1SD...	GRD	11Jun2016	47	11669
Subset_S1B_IW_GRDH_1SD...	GRD	15Nov2017	47	8298
Subset_S1B_IW_GRDH_1SD...	GRD	10Nov2018	47	13548
Subset_S1B_IW_GRDH_1SD...	GRD	30Sep2019	47	18273

5 Products

Target Folder

Save as: BEAM-DIMAP

Directory: D:\DRAGON2019\Final Dataset\GRD\_processed

Skip existing target files  Keep source product name

Run remote Load Graph Run Close Help

File Graphs

I/O Parameters Apply-Orbit-File Calibration Terrain-Correction Write

File Name	Type	Acquisition	Track	Orbit
Subset_S1A_IW_GRDH_1SD...	GRD	03Oct2015	47	7994
Subset_S1A_IW_GRDH_1SD...	GRD	11Jun2016	47	11669
Subset_S1B_IW_GRDH_1SD...	GRD	15Nov2017	47	8298
Subset_S1B_IW_GRDH_1SD...	GRD	10Nov2018	47	13548
Subset_S1B_IW_GRDH_1SD...	GRD	30Sep2019	47	18273

5 Products

Target Folder

Save as: BEAM-DIMAP

Directory: D:\DRAGON2019\Final Dataset\GRD\_processed

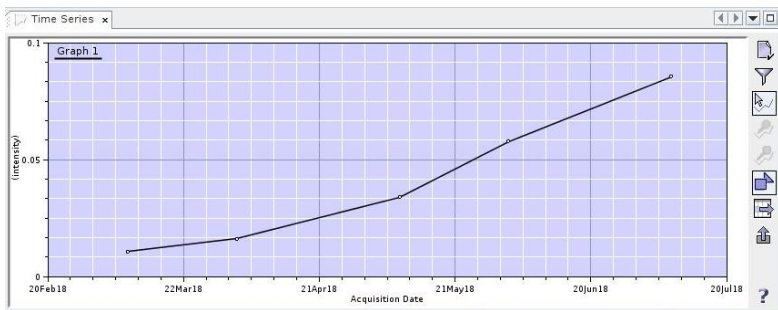
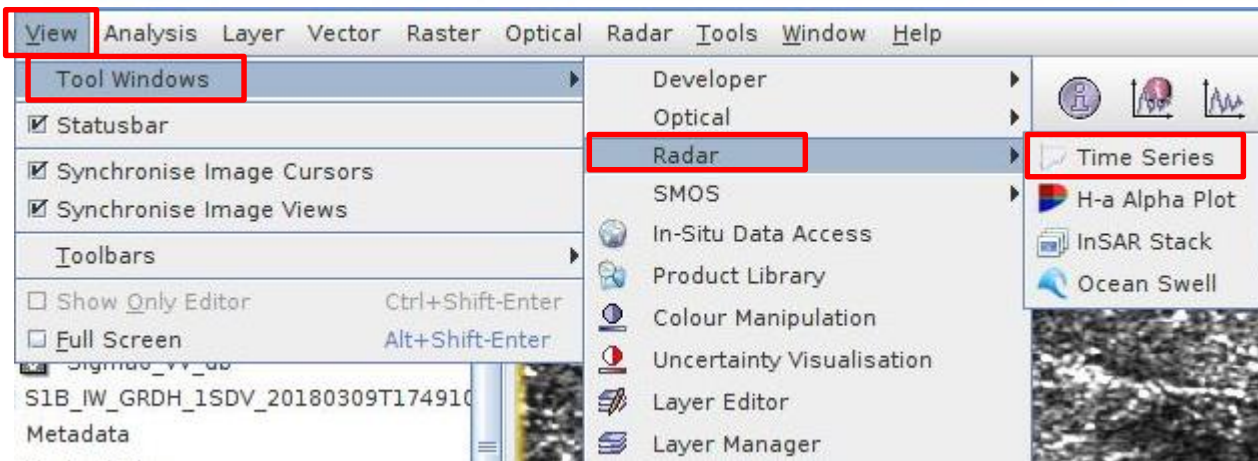
Skip existing target files  Keep source product name

Run remote Load Graph Run Close Help

Open previously saved graph GRD\_Cal\_TC.xml



# Time series analysis



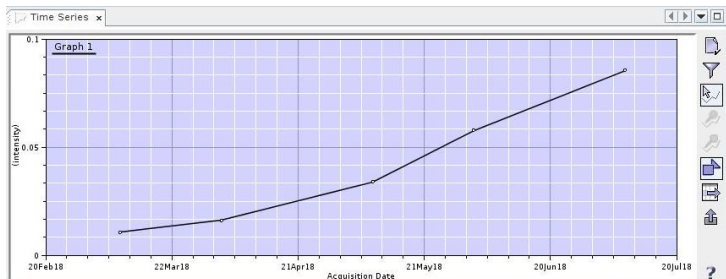
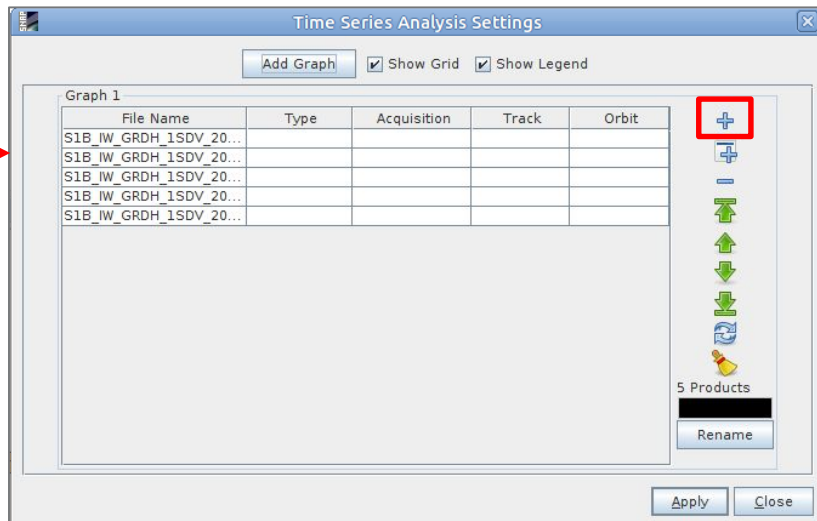
→ Add your data products



# Time series analysis



Choose your processed data products



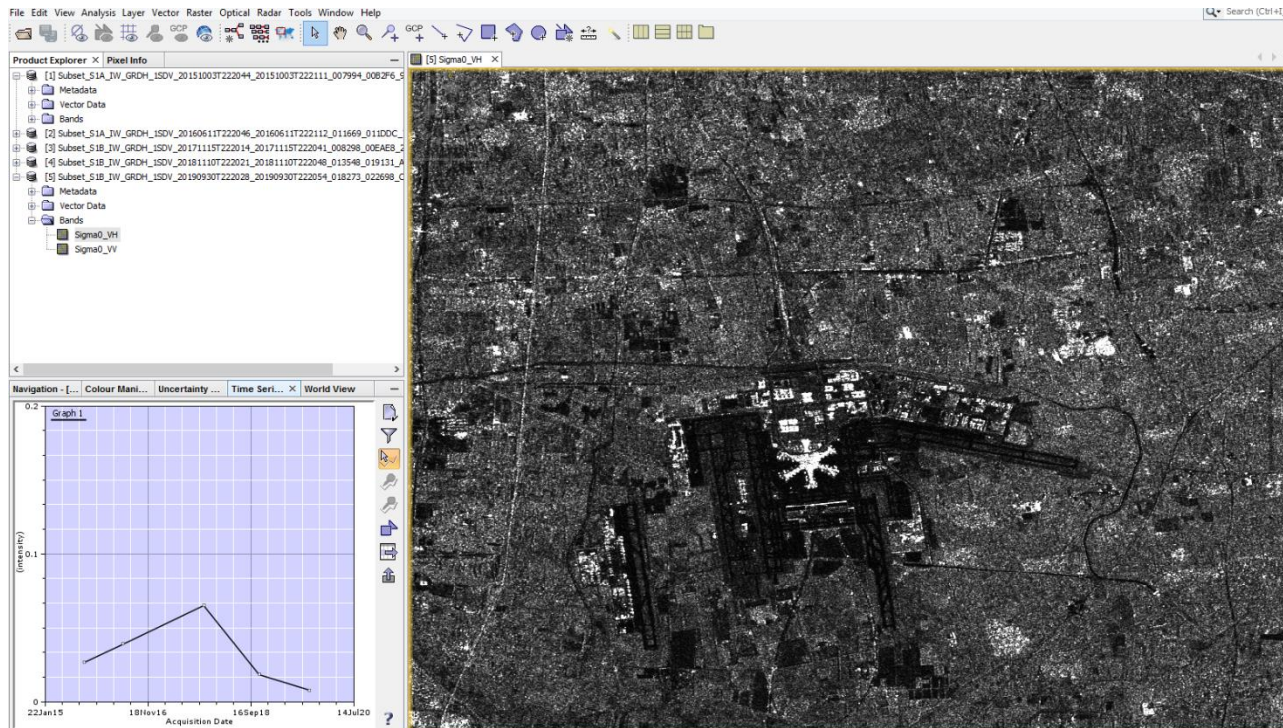
Bands filter



Show plot at cursor position



# Time series analysis



→ One of the plotted bands has to be opened



- Creating a subset of S1 GRDH images

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  - Compensate for geometric distortions caused by topographical variations of a scene and the tilt of satellite sensor*

- Creating a multitemporal stack

  - Collocation spatially overlapping products (based on geolocation)*

- Speckle filtering

  - Filtering the inherent salt and pepper like texturing called speckles*

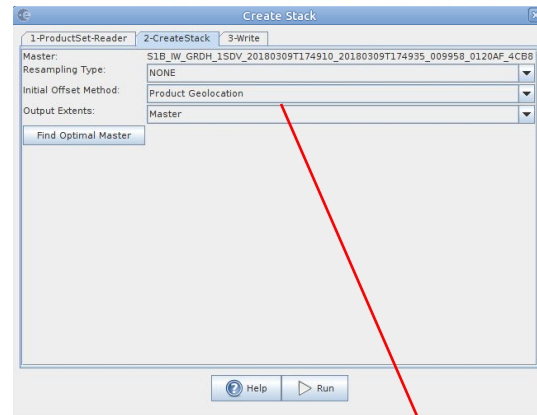
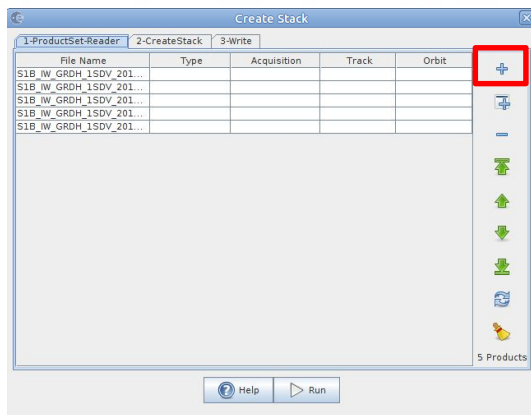
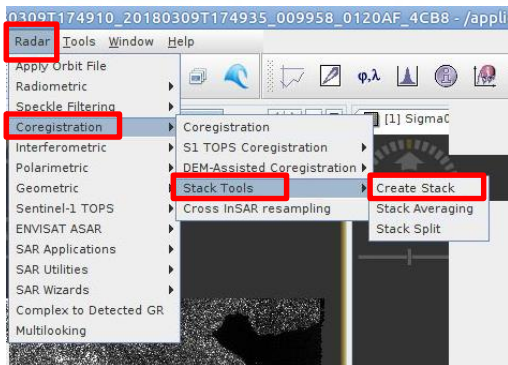
- Linear to dB conversion

  - Compensate for very high dynamic range in visualisation*

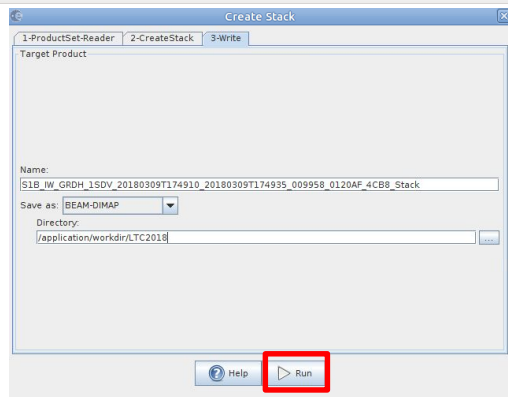
- Stack statistics and analysis of temporal backscatter signatures



# Creating multitemporal stack



Collocating spatially overlapping images

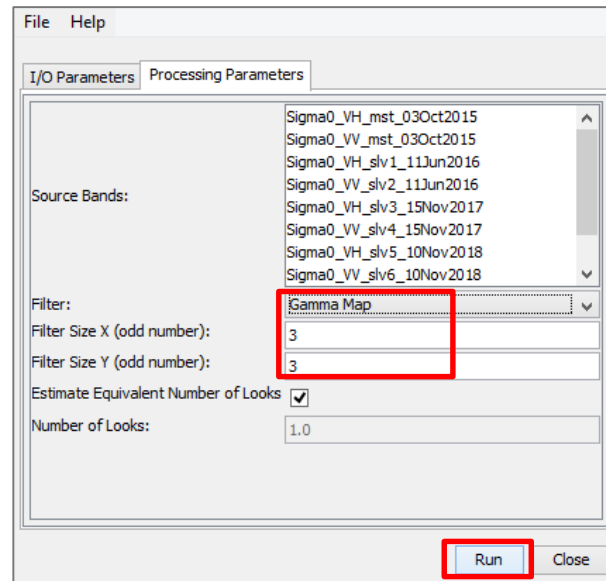
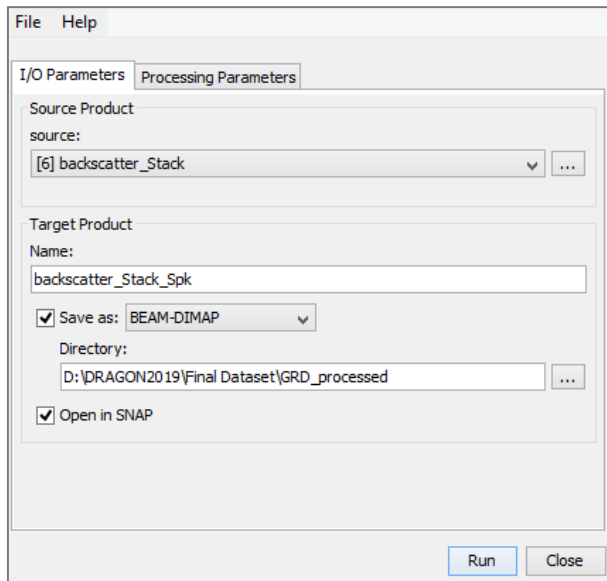
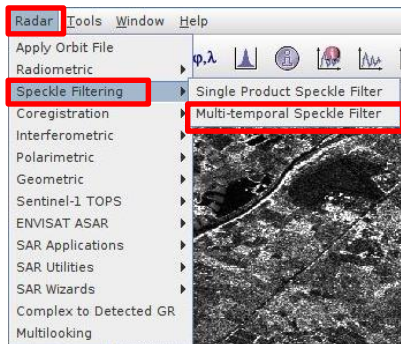


- *Product geolocation (if terrain corrected)*
- *Orbits (if not terrain corrected)*



- Creating a subset of S1 GRDH images
  - Spatial subset depending on the AOI*
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- Creating a multitemporal stack
  - Collocation spatially overlapping products (based on geolocation)*
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- Stack statistics and analysis of temporal backscatter signatures

# Multitemporal speckle filtering



Spatial filtering with weighted average of selected filter across the images of the time series



# Multitemporal speckle filtering



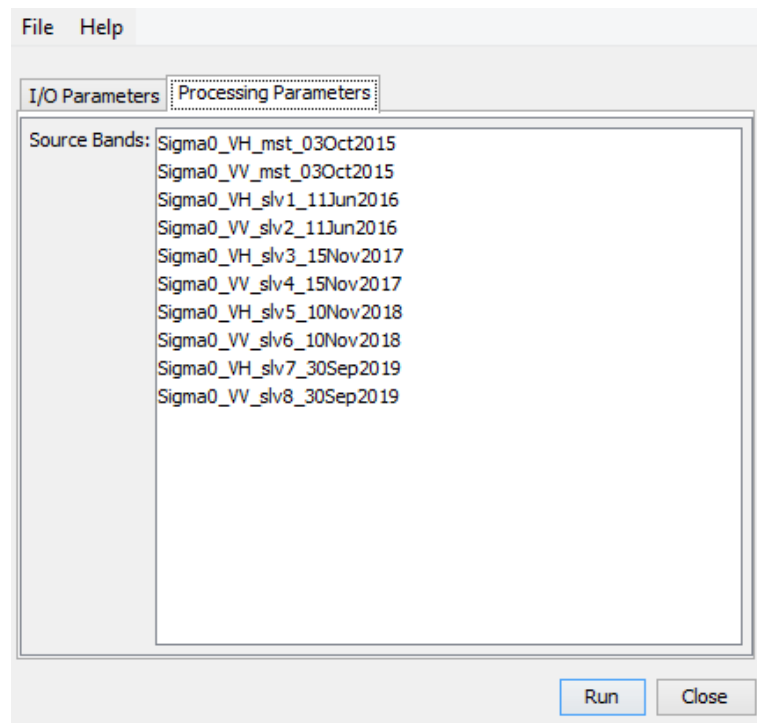
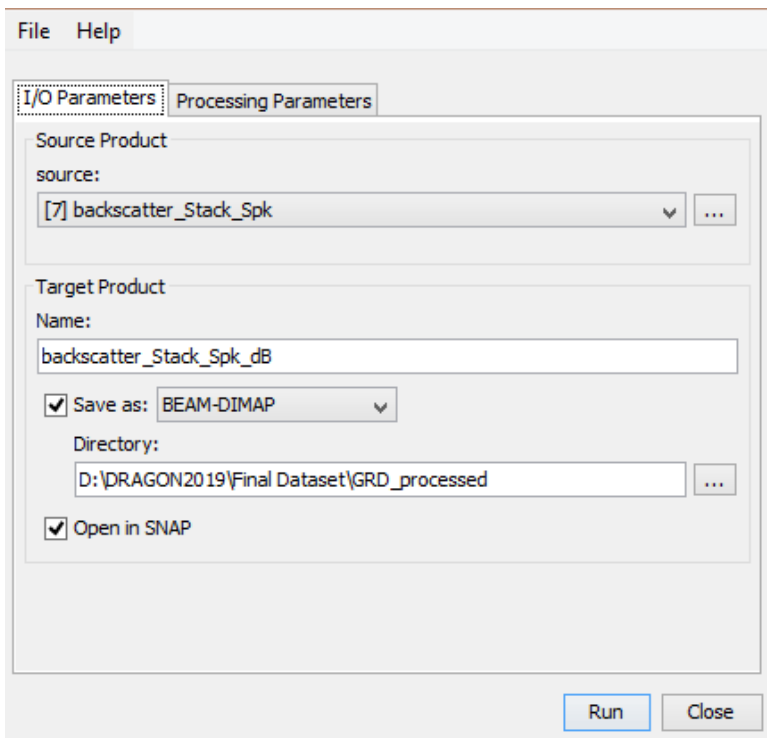
- Creating a subset of S1 GRDH images
  - Spatial subset depending on the AOI*
- Updating orbits
- Radiometric calibration
  - Conversion of image intensity to sigma0 providing the radar backscatter*
- Terrain correction
  - Compensate for geometric distortions caused by topographical variations of a scene and the tilt of satellite sensor*
- Creating a multitemporal stack
  - Collocation spatially overlapping products (based on geolocation)*
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- Linear to dB conversion
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- Stack statistics and analysis of temporal backscatter signatures

# Conversion from linear to dB

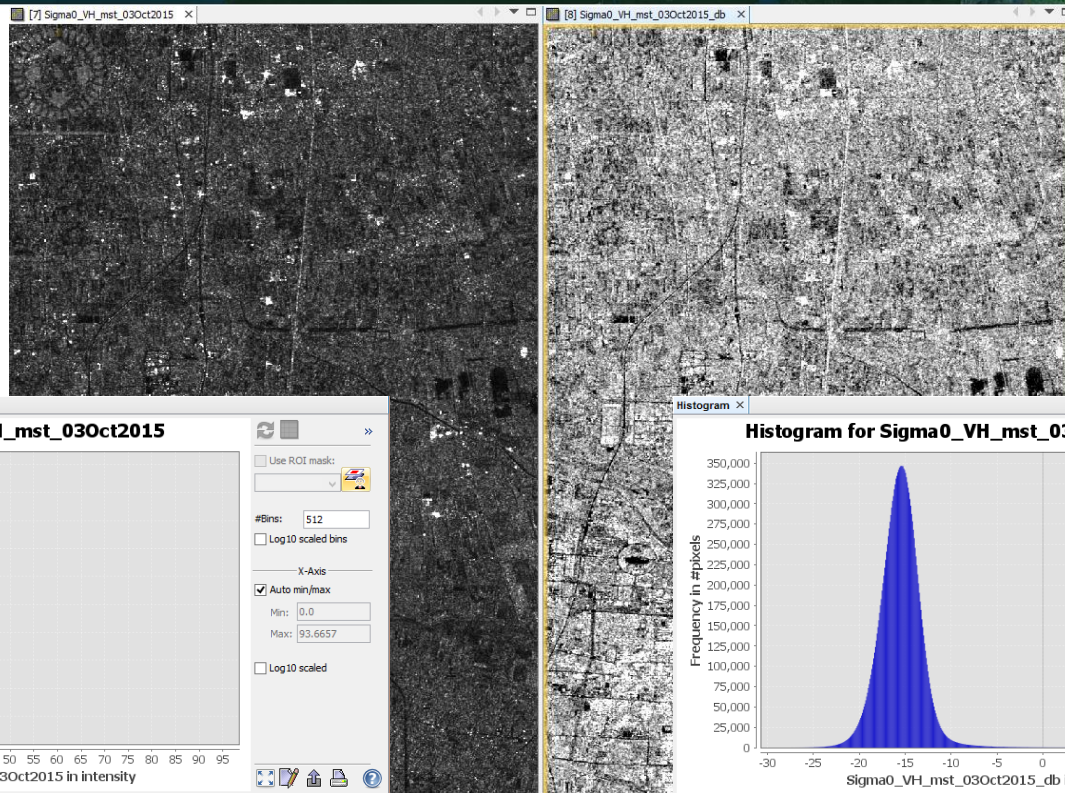


The screenshot shows the ENVI software interface. The 'Raster' menu is open, and 'Data Conversion' is selected. A sub-menu is displayed with 'Converts bands to/from dB' highlighted. The main window shows two side-by-side radar images of a city area, with the right image being the converted dB version. A map in the bottom left shows the location of the data in China, with a red box highlighting the area of interest near Lanzhou. The map includes labels for various cities and provinces: Changde, Chengde, Shunyi, Beijing, Daxing, Lanzhou, Tangshan, Tianjin, Henan, Baoding, Dingzhou, Cangzhou, and Shijiazhuang. A 50 km scale bar is also present.

# Conversion from linear to dB



# Linear vs dB comparison





- Creating a subset of S1 GRDH images
  - Spatial subset depending on the AOI*
- Updating orbits
- Radiometric calibration
  - Conversion of image intensity to sigma0 providing the radar backscatter*
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  - Compensate for geometric distortions caused by topographical variations of a scene and the tilt of satellite sensor*
- Creating a multitemporal stack
  - Collocation spatially overlapping products (based on geolocation)*
- Speckle filtering
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- Linear to dB conversion
  - Compensate for very high dynamic range in visualisation*
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# Visual inspection of the time series



File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Product Explorer

- Sigma0\_VV\_slv2\_11Jun2016
- Sigma0\_VH\_slv3\_15Nov2017
- Sigma0\_VV\_slv4\_15Nov2017
- Sigma0\_VH\_slv5\_10Nov2018
- Sigma0\_VV\_slv6\_10Nov2018
- Sigma0\_VH\_slv7\_30Sep2019
- Sigma0\_VV\_slv8\_30Sep2019
- backscatter\_Stack\_Spk\_db
- Metadata
- Vector Data
- Bands
  - Sigma0\_VH\_mst\_03Oct2015\_db
  - Sigma0\_VV\_mst\_03Oct2015\_db
  - Sigma0\_VH\_slv1\_11Jun2016\_db
  - Sigma0\_VV\_slv2\_11Jun2016\_db
  - Sigma0\_VH\_slv3\_15Nov2017\_db
  - Sigma0\_VV\_slv4\_15Nov2017\_db
  - Sigma0\_VH\_slv5\_10Nov2018\_db
  - Sigma0\_VV\_slv6\_10Nov2018\_db
  - Sigma0\_VH\_slv7\_30Sep2019\_db
  - Sigma0\_VV\_slv8\_30Sep2019\_db

Navigator

Editor: Basic Sliders Table

Name: Sigma0\_VV\_mst\_03Oct2015\_db  
Unit: intensity\_db  
Min: -21.463  
Max: 16.462

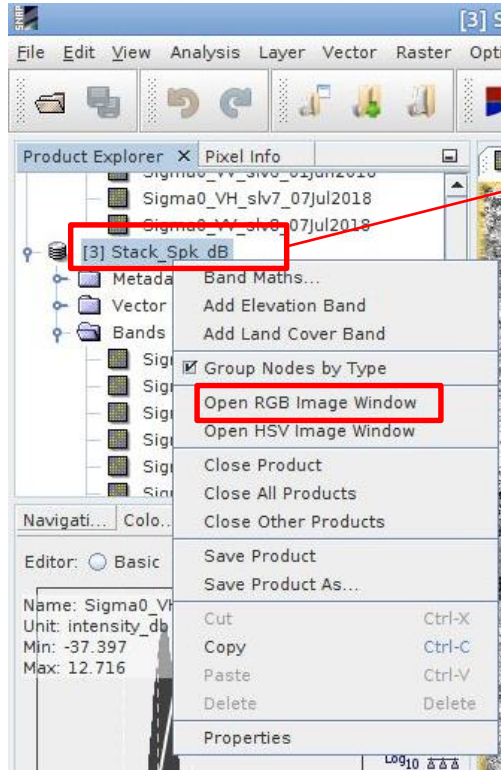
Rough statistics

8.7 1.398 1.06 4.13

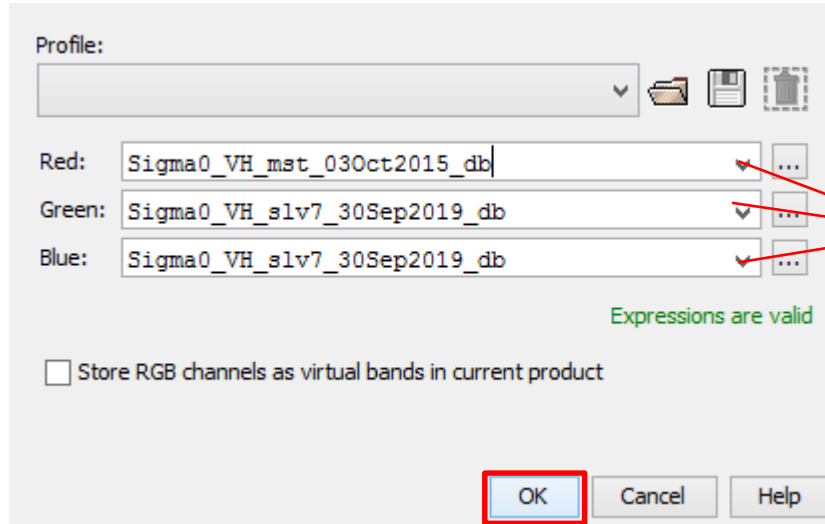
More Options

Product Library Layer Manager Mask Manager

# RGB Composite



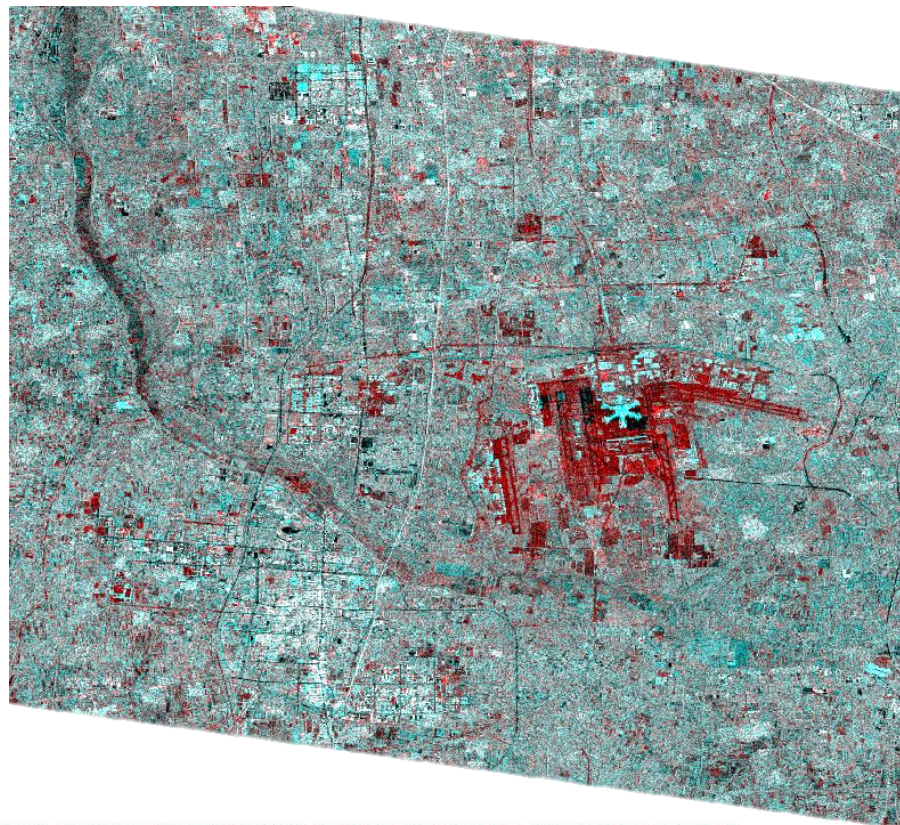
Right click on the product



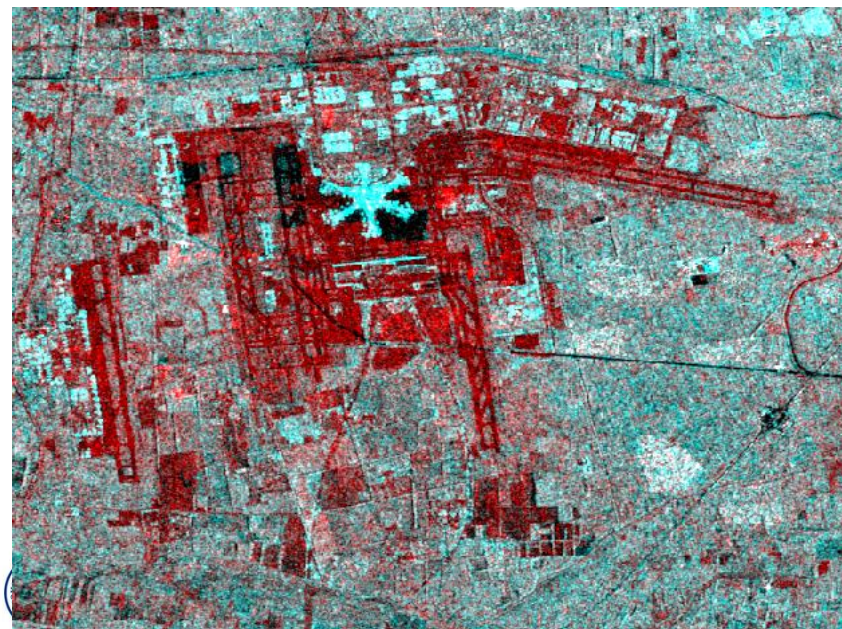
Band selection



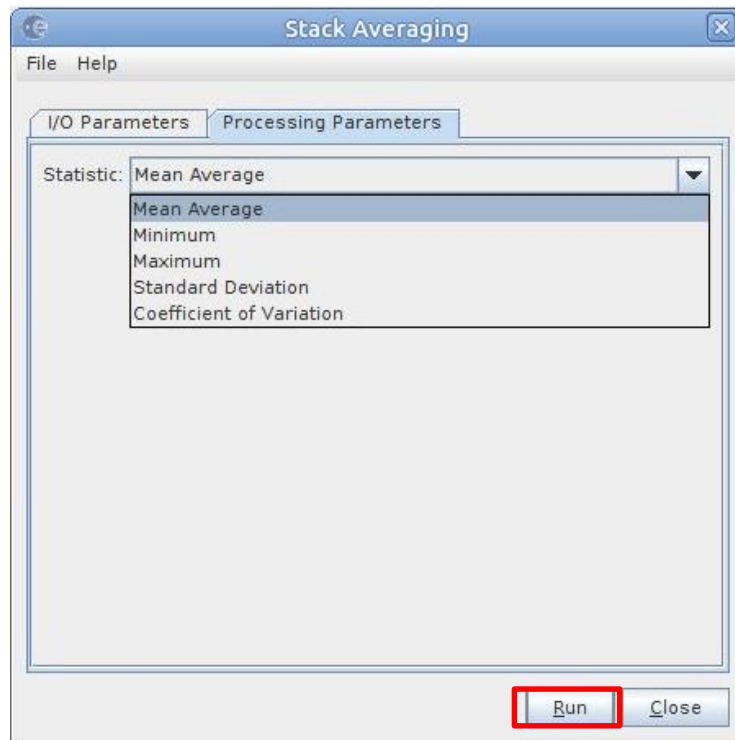
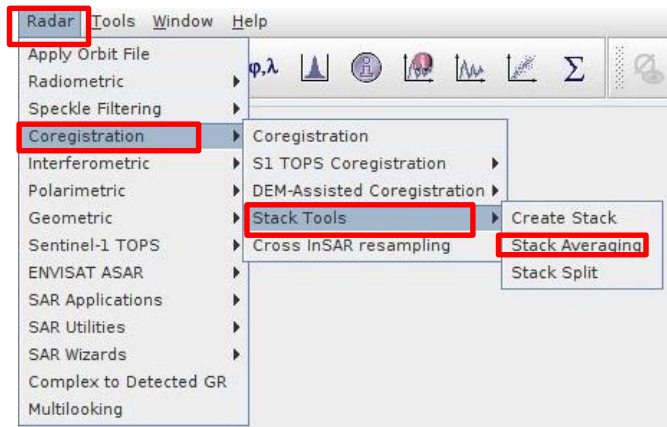
# RGB Composite



Red – high backscatter in 2015, low backscatter in 2019  
Cyan – low backscatter in 2015, high in 2019



# Stack averaging



# Stack averaging – RGB Composite



*RGB combination for land cover classification*

Dual Pol Ratio Sigma0 VV+VH

Red:	<input type="text" value="Sigma0_VV"/>	▼	...
Green:	<input type="text" value="Sigma0_VH"/>	▼	...
Blue:	<input type="text" value="Sigma0_VV/Sigma0_VH"/>	▼	...

