



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)



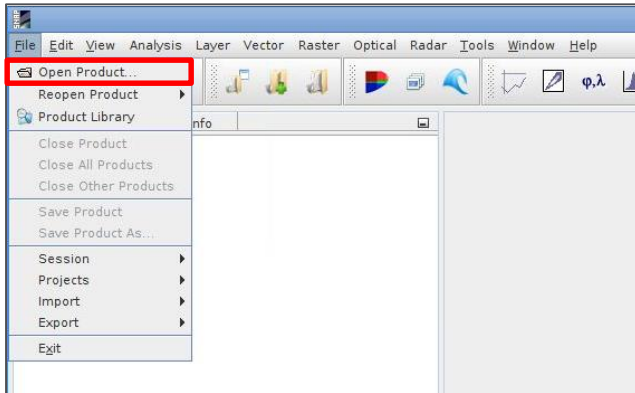
Input data: time series of Sentinel-1 GRDH images over China

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:

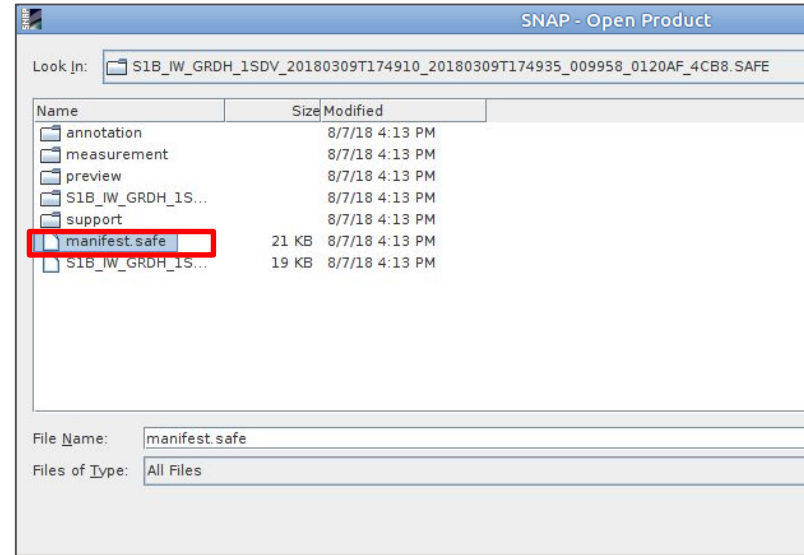
- temporal backscatter signatures for various land cover types
- change detection

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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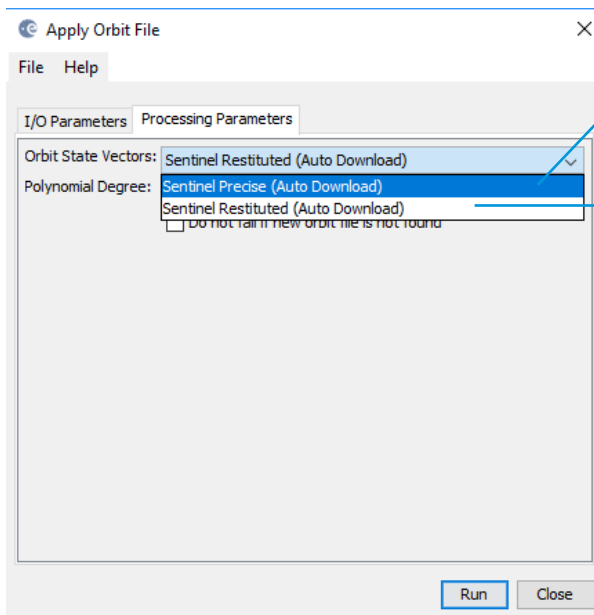
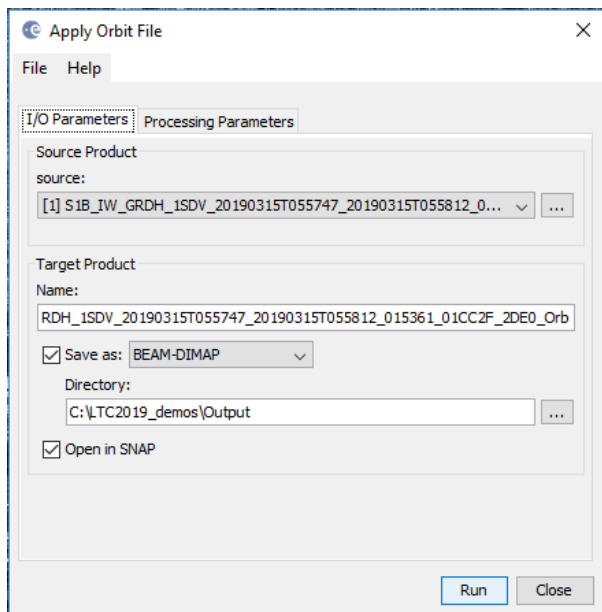
- Linear to dB conversion

 - 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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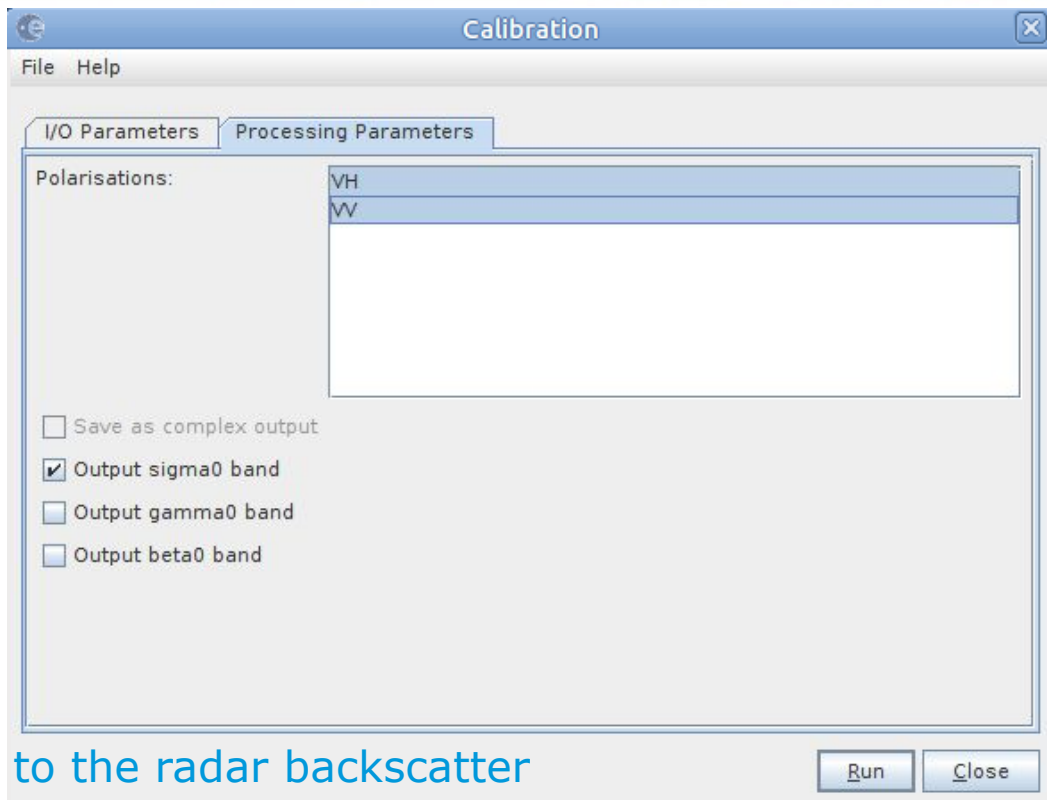
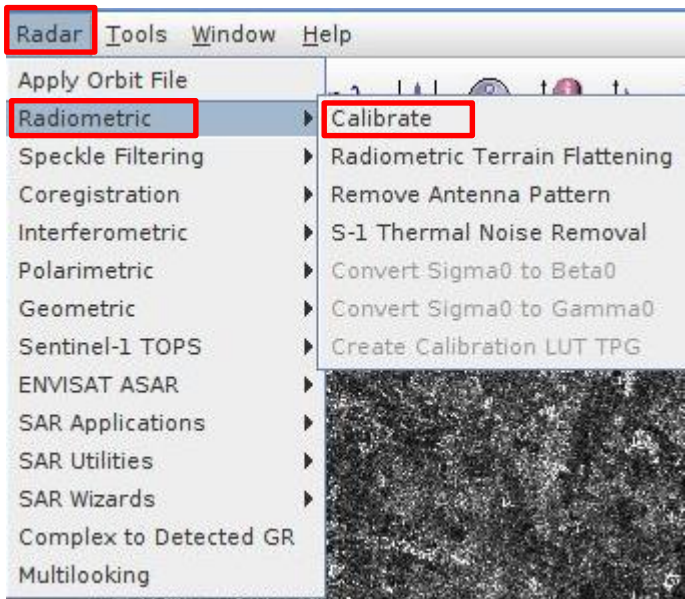
- Stack statistics and analysis of temporal backscatter signatures

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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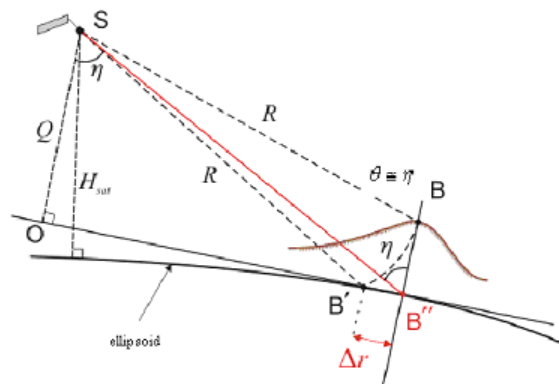
- Speckle filtering

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

- Linear to dB conversion

 - Compensate for very high dynamic range in visualisation*

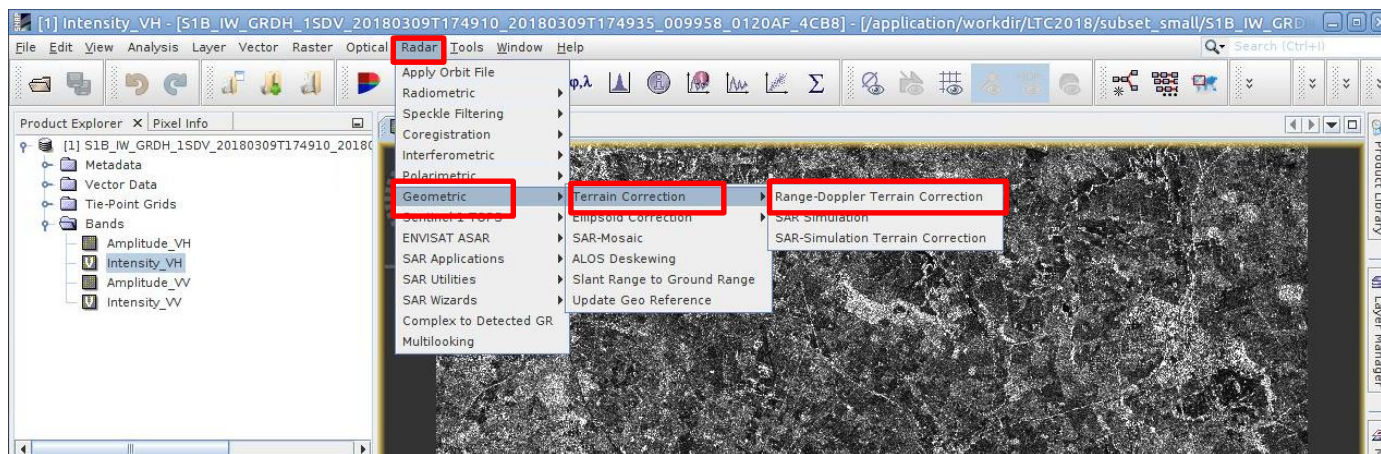
- Stack statistics and analysis of temporal backscatter signatures



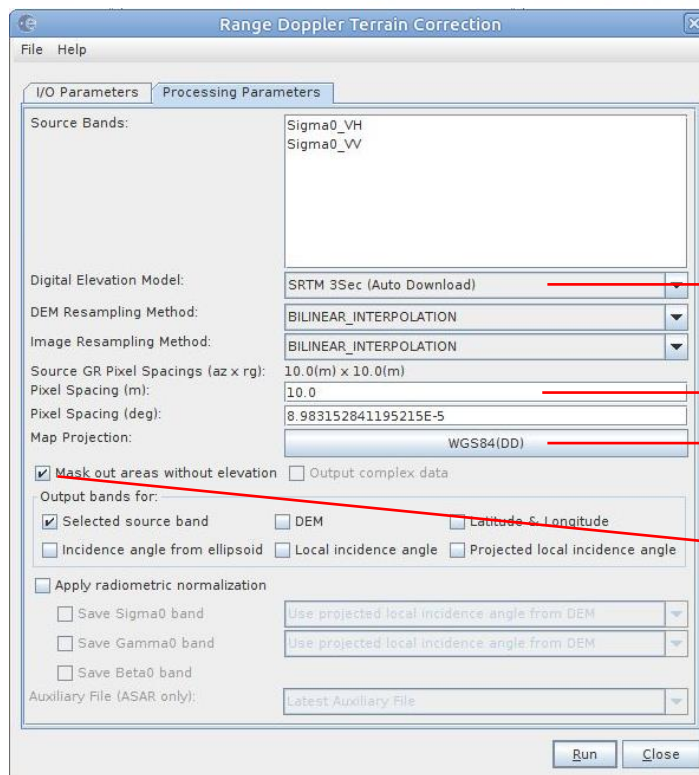
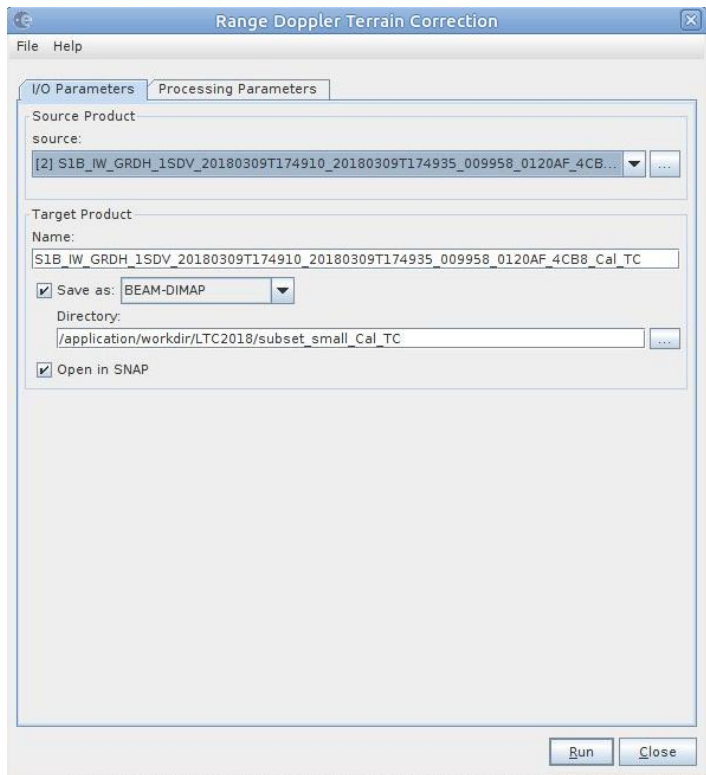
Point **B** with elevation **h** above the ellipsoid is imaged at position **B'** in SAR image, though its real position is **B''**. The offset Δr between **B'** and **B''** exhibits the effect of topographic distortions

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

Radar / Geometric / Terrain Correction / Range Doppler Terrain Correction



Terrain correction & Geocoding



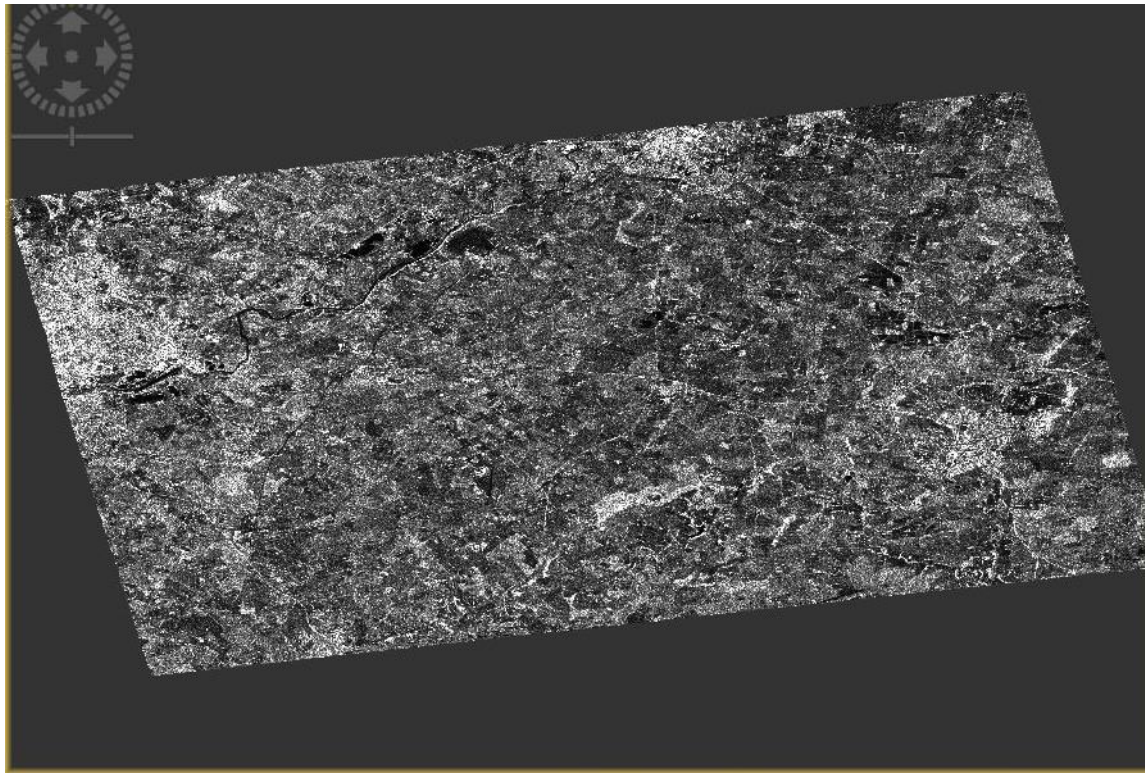
DEM selection

Pixel spacing

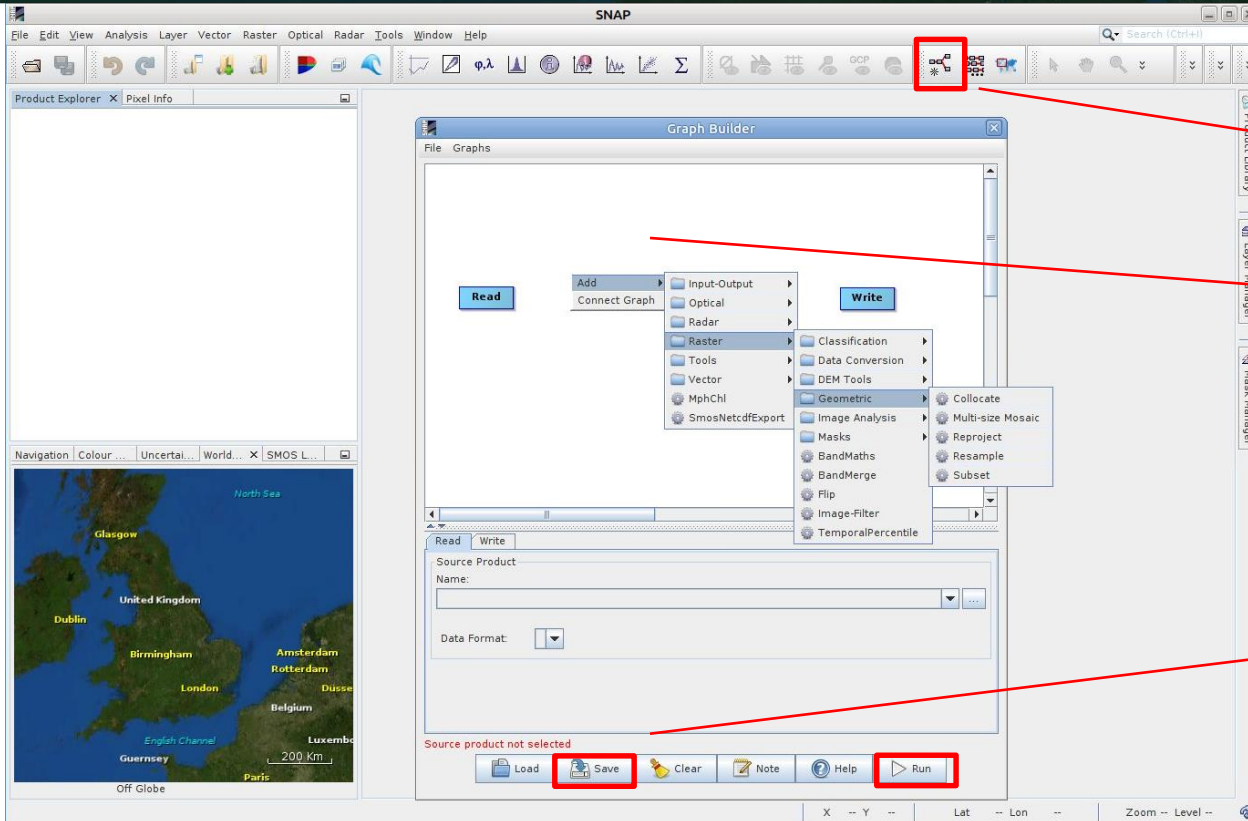
Map projection

Masking areas without elevation





Automatic Processing with Graph



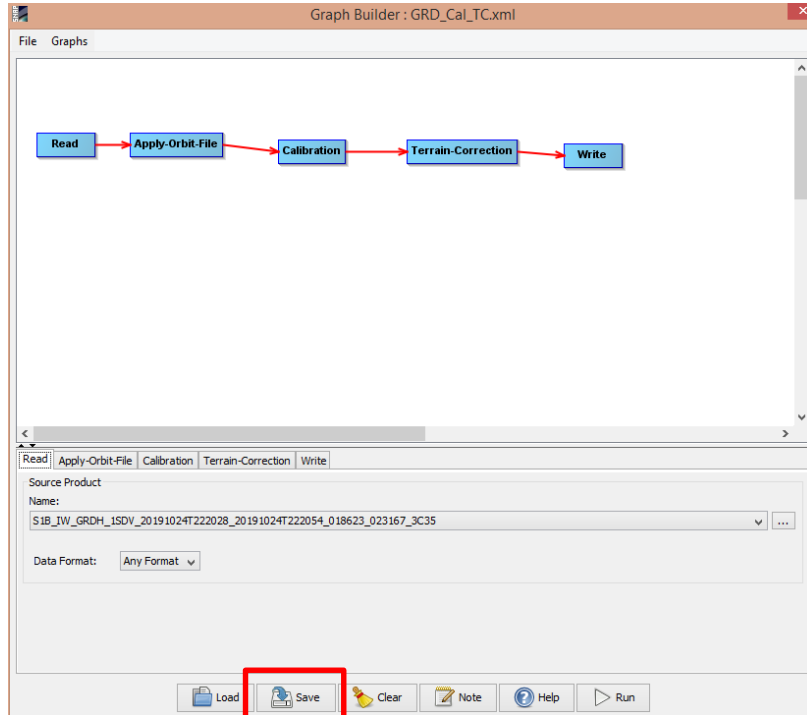
Graph Builder

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

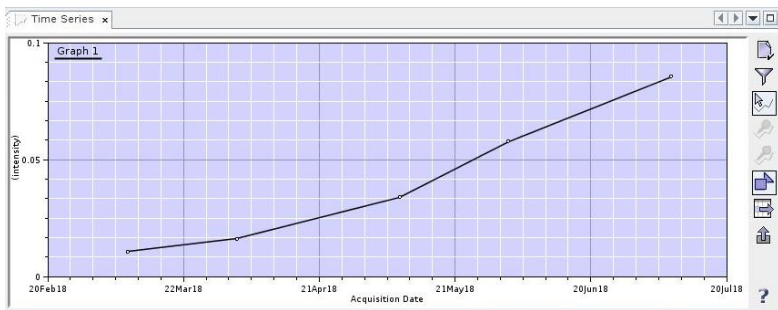
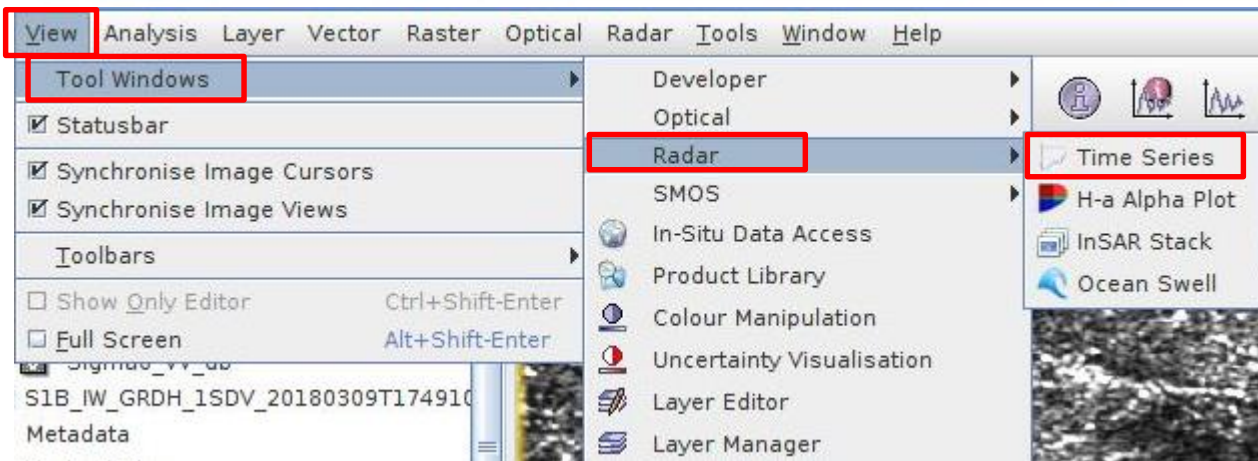
Skip existing target files Keep source product name

Run remote Load Graph Run Close Help

Open previously saved graph GRD_Cal_TC.xml



Time series analysis



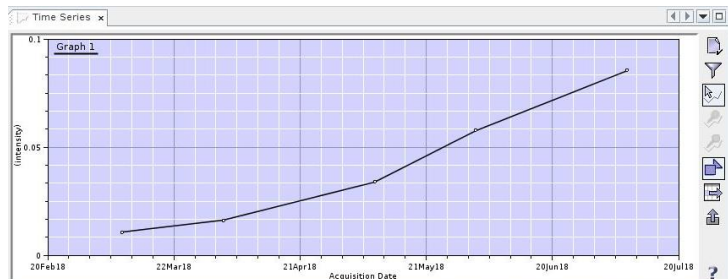
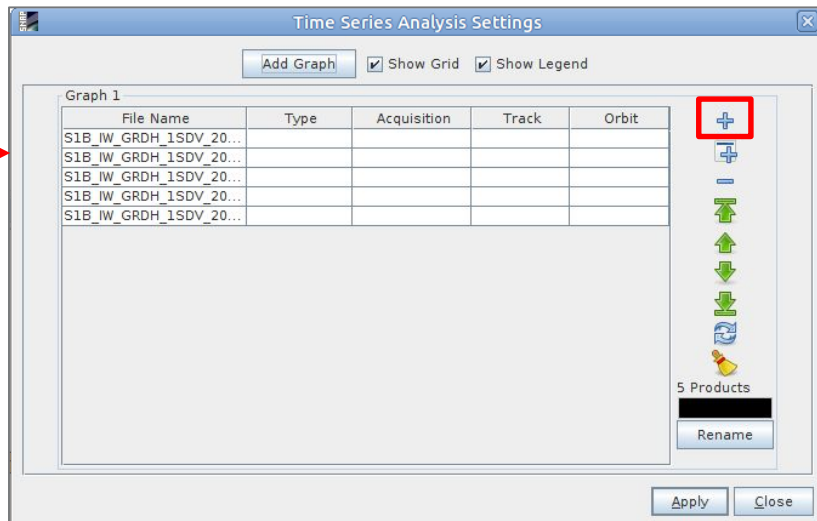
→ Add your data products



Time series analysis



Choose your processed data products



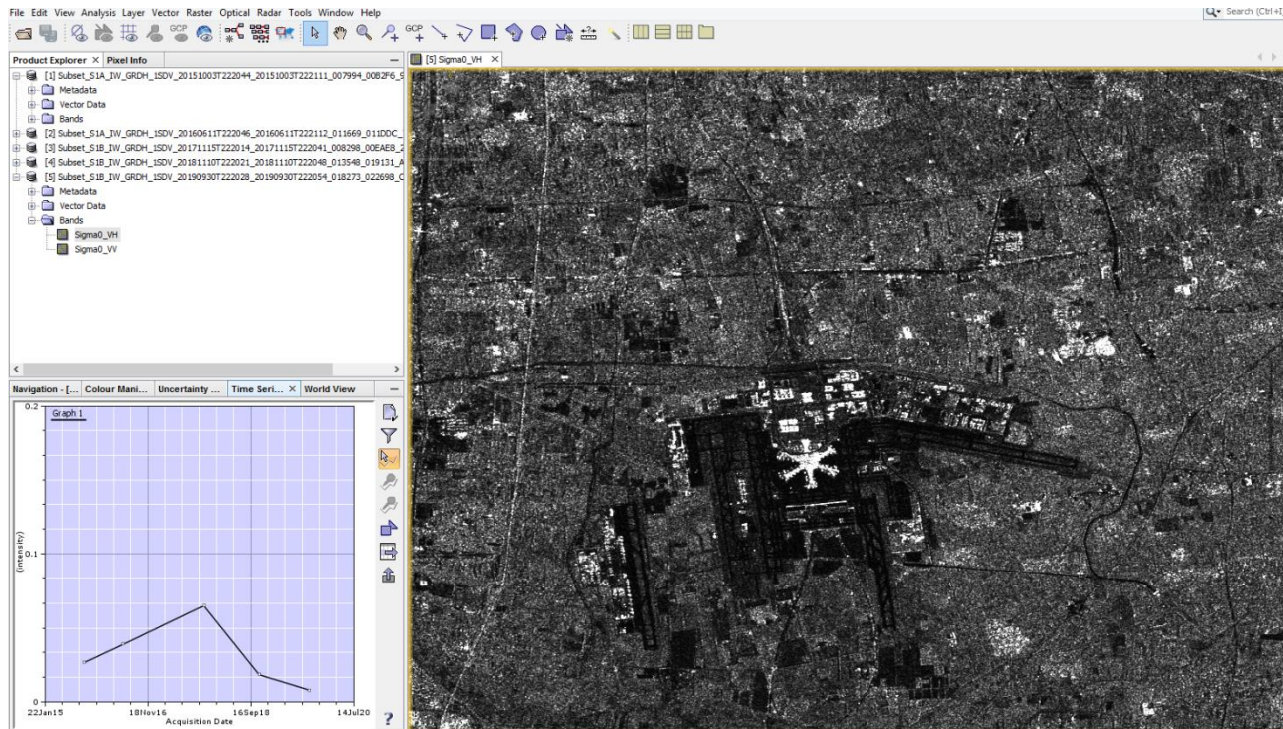
Bands filter



Show plot at cursor position



Time series analysis



→ One of the plotted bands has to be opened



- Creating a subset of S1 GRDH images

 - Spatial subset depending on the AOI*

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- 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

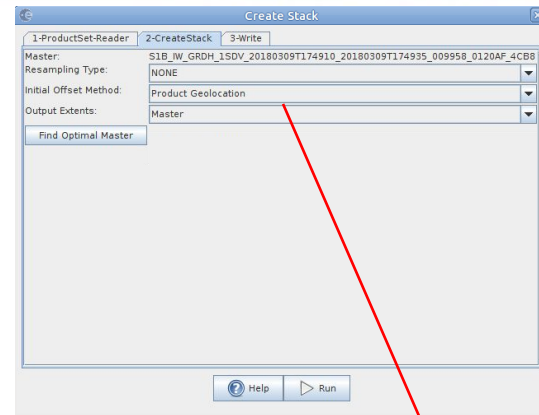
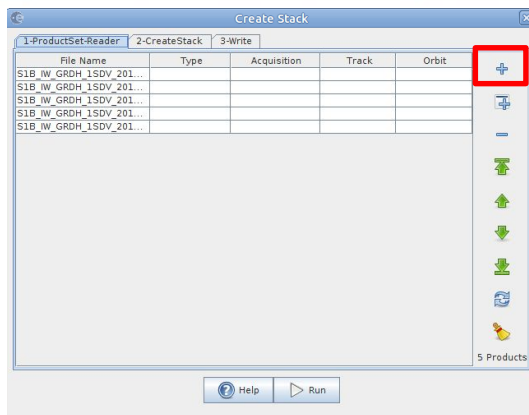
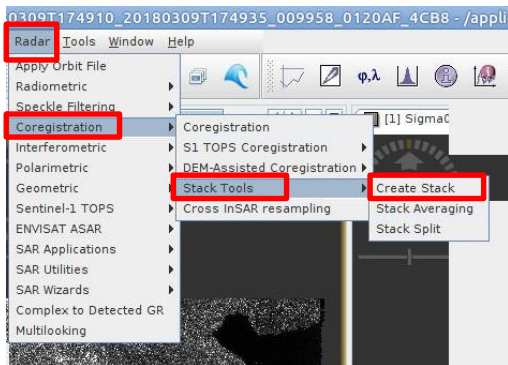
 - Filtering the inherent salt and pepper like texturing called speckles*

- Linear to dB conversion

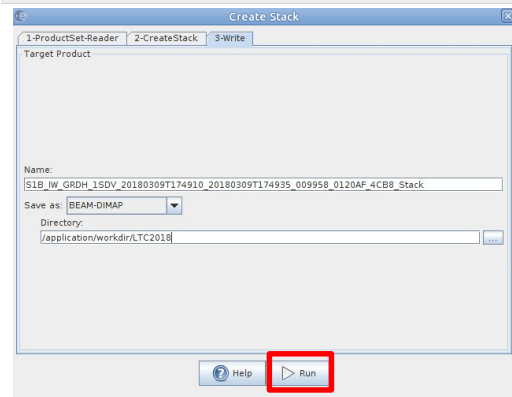
 - Compensate for very high dynamic range in visualisation*

- Stack statistics and analysis of temporal backscatter signatures

Creating multitemporal stack



Collocating spatially overlapping images



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



- Creating a subset of S1 GRDH images

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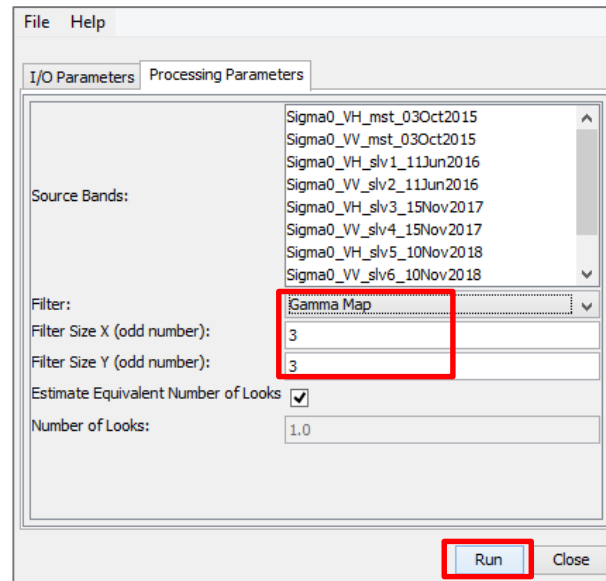
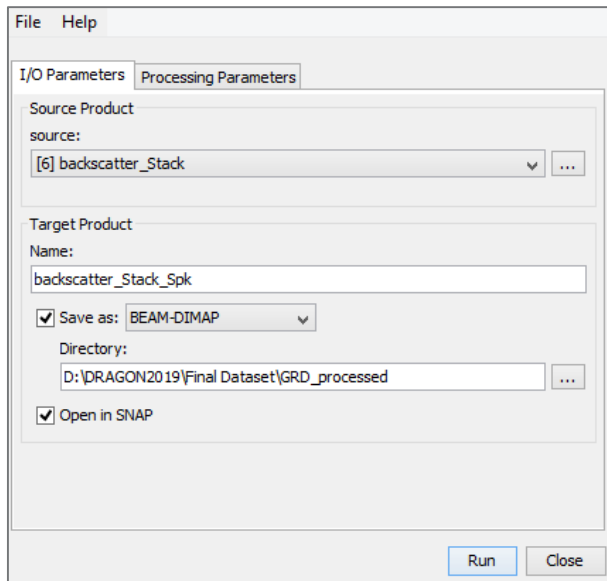
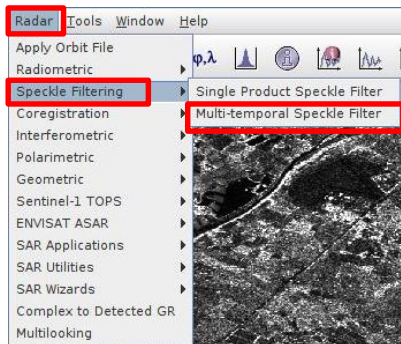
 - Filtering the inherent salt and pepper like texturing called speckles*

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Multitemporal speckle filtering



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



Multitemporal speckle filtering



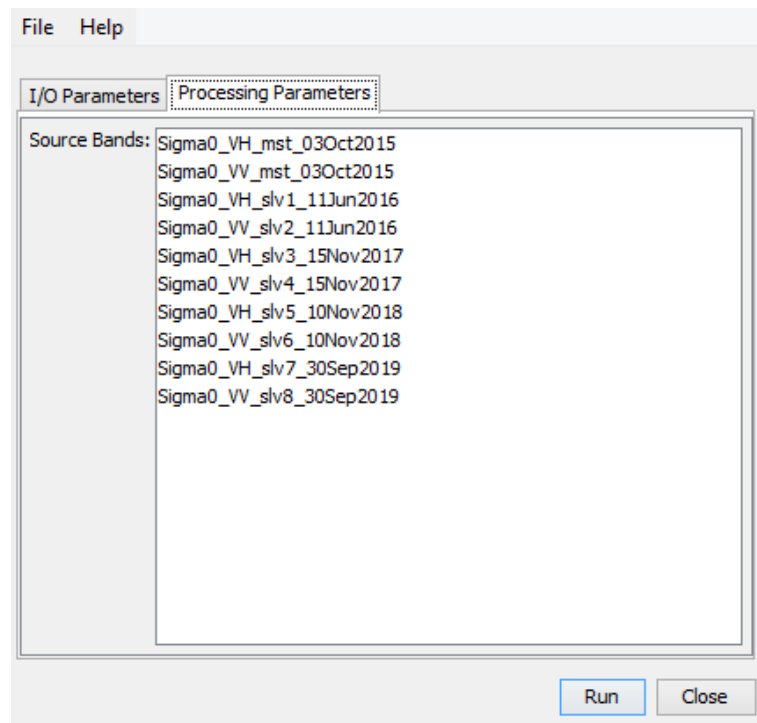
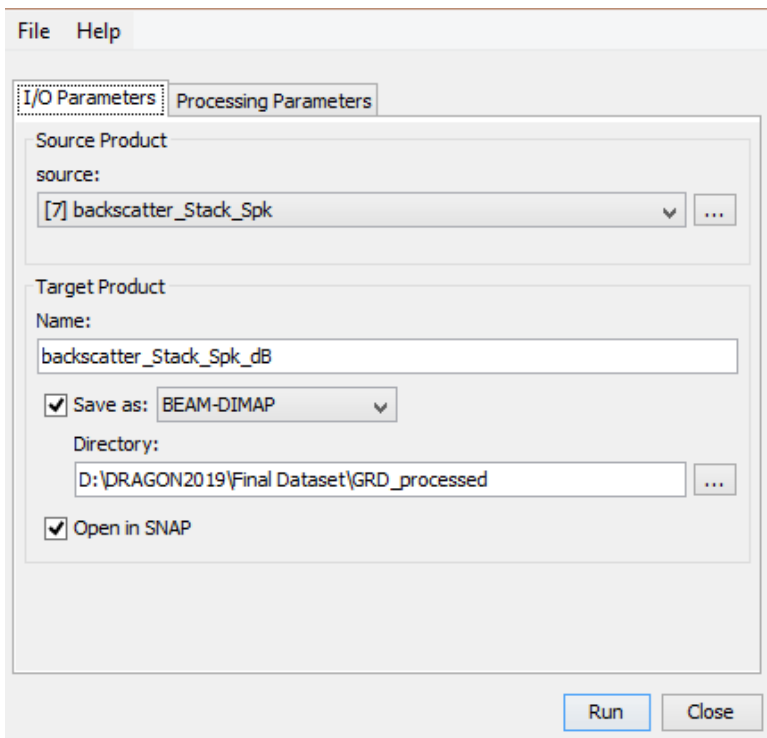
- Creating a subset of S1 GRDH images
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Conversion from linear to dB

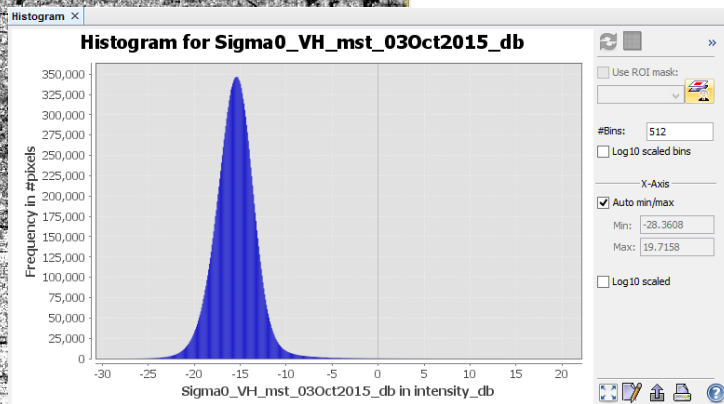
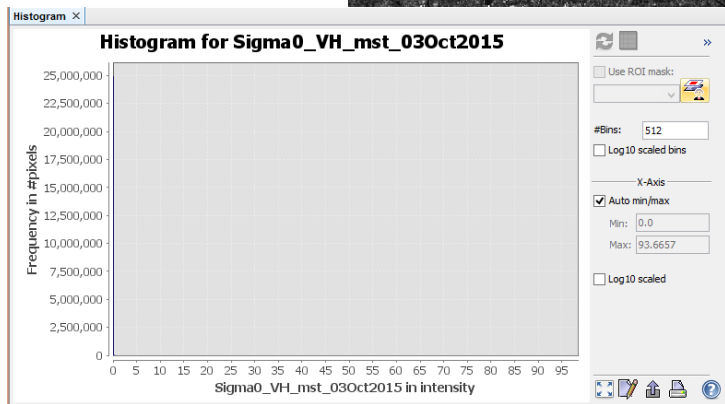
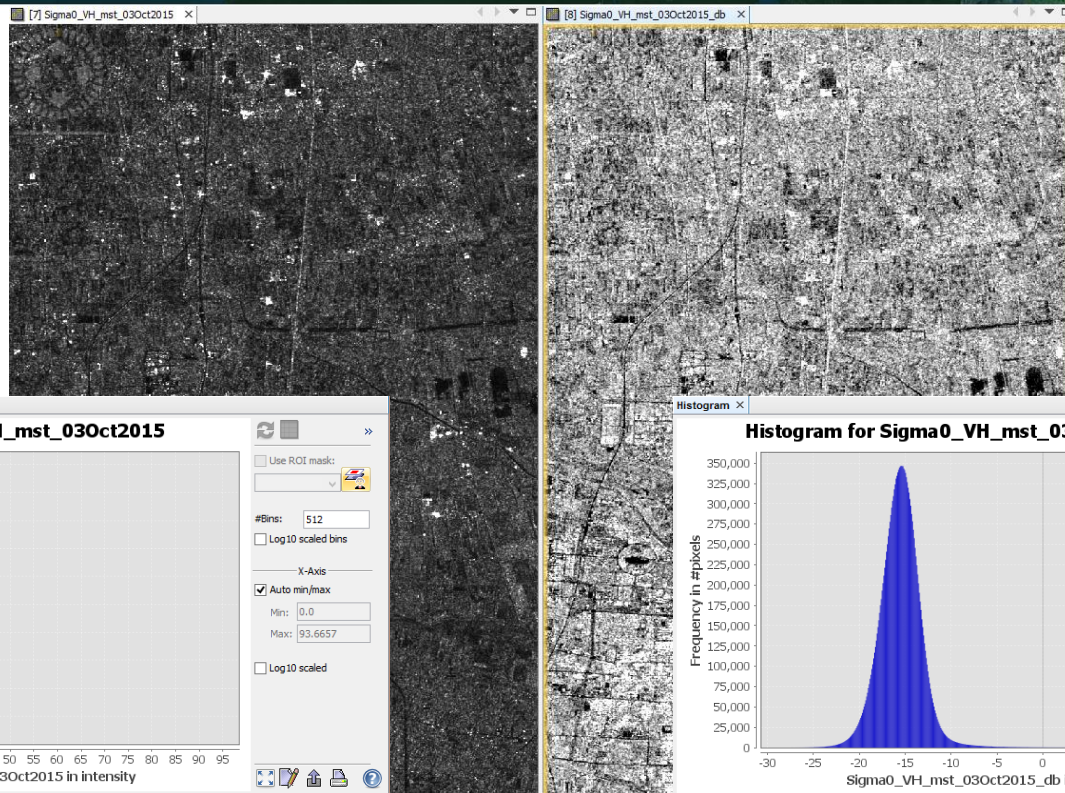


The screenshot shows the ENVI software interface. The 'Raster' menu is open, and 'Data Conversion' is selected. The 'Convert Datatype' sub-menu is also open, with 'Converts bands to/from dB' highlighted. The main window displays two side-by-side images of a city area, showing the difference between the original linear data and the converted dB data. A map in the bottom left corner shows the location of the data in China, with a red box highlighting the area around Lanzhou.

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
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Visual inspection of the time series



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

Search (Ctrl+F)

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

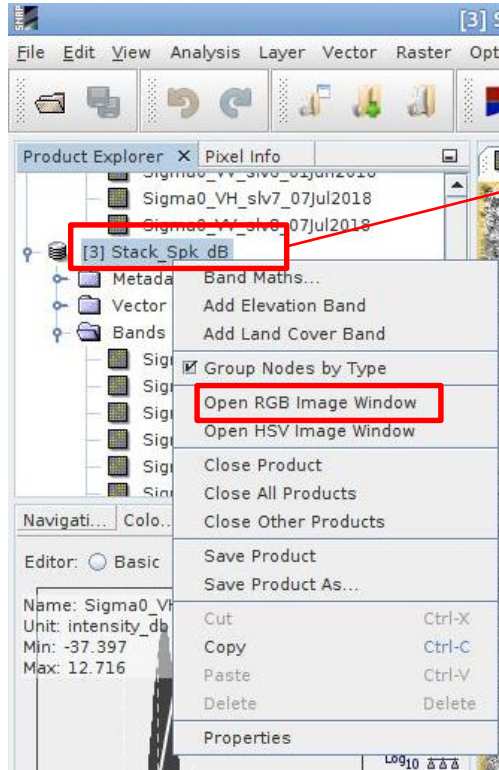
8.398 4.06 4.13

More Options

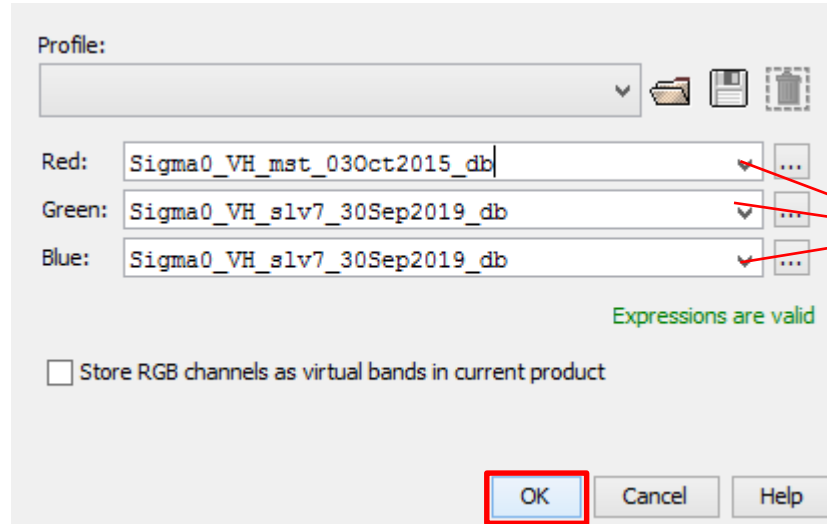
Product Library
Layer Manager
Mask Manager

[8] Sigma0_VV_mst_03Oct2015...
[8] Sigma0_VV_slv2_11Jun2016...
[8] Sigma0_VV_slv4_15Nov2017...
[8] Sigma0_VV_slv6_10Nov2018...
[8] Sigma0_VV_slv8_30Sep2019_db...

RGB Composite



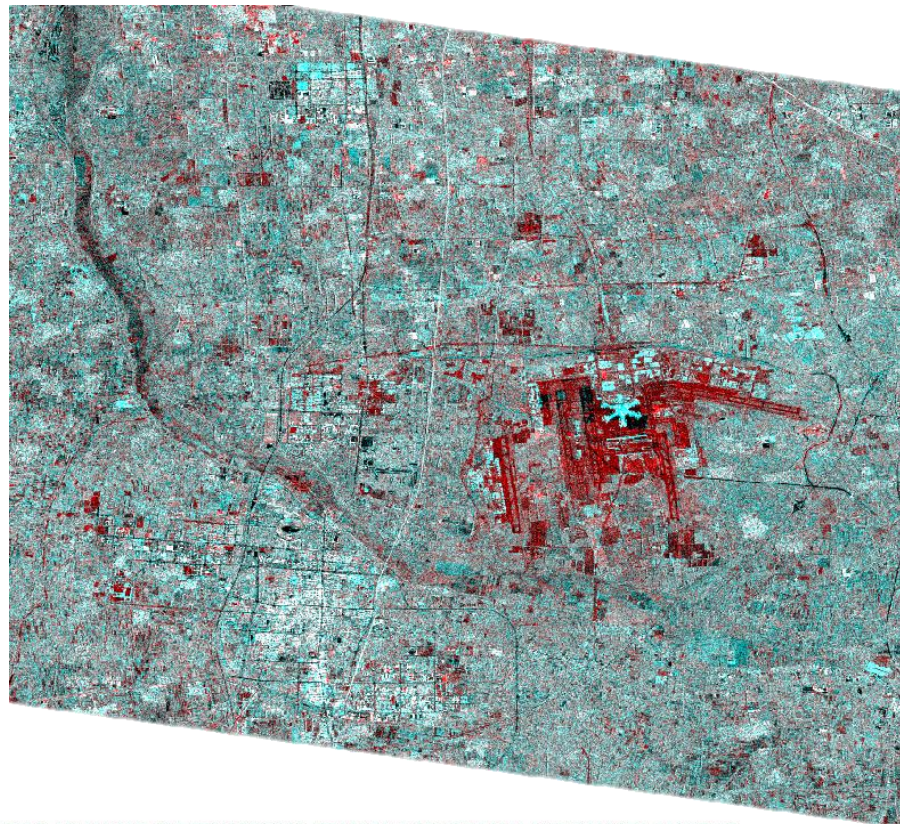
Right click on the product



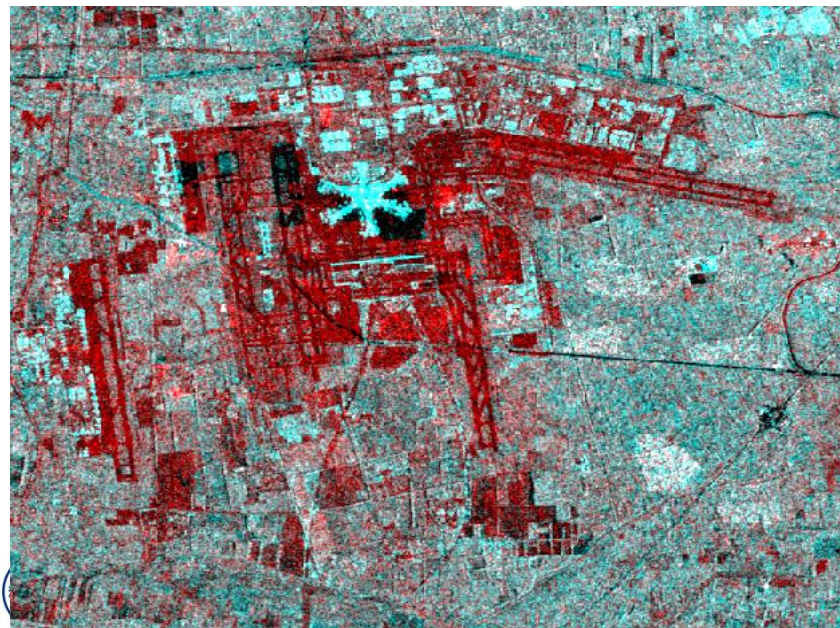
Band selection



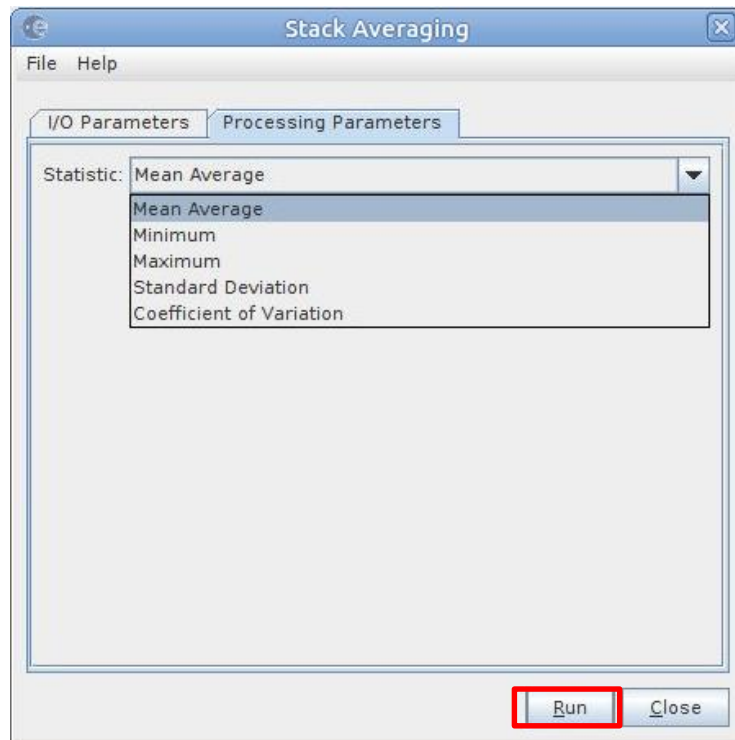
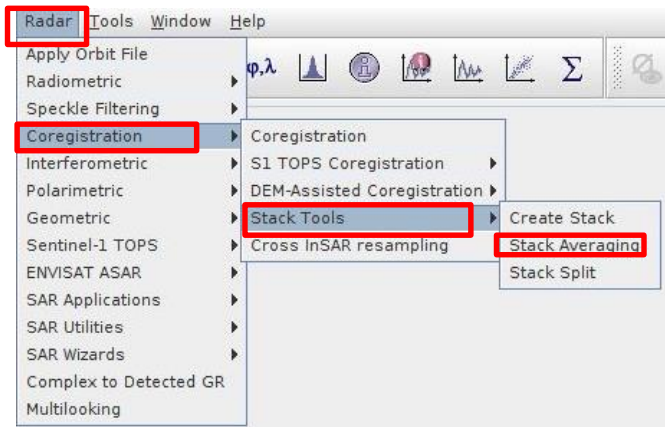
RGB Composite



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



Stack averaging



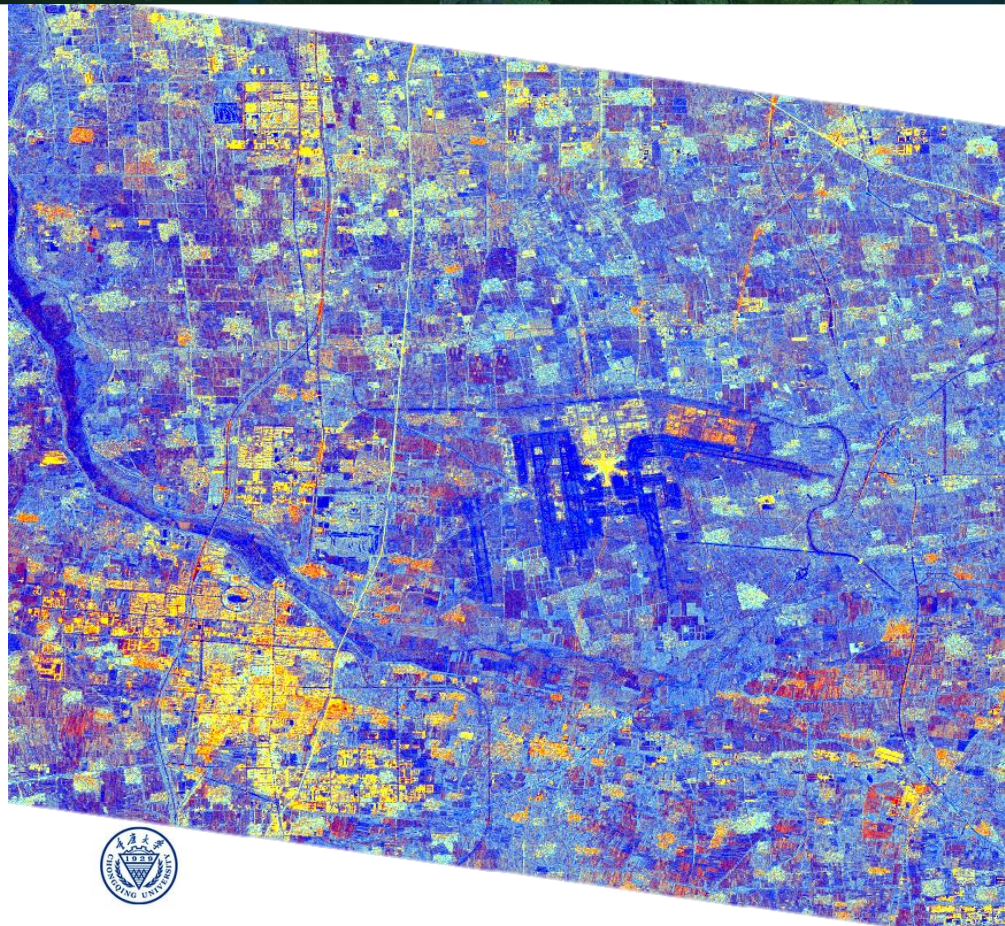
Stack averaging – RGB Composite



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"/>	▼	...





Part 1

Multitemporal Analysis using SAR Coherence-Intensity composites



Objectives



- Familiarizing with Sentinel-1 SLC products
- Calculation of backscatter intensity from Sentinel-1 SLC products
- Calculation of interferometric coherence
- Analysis of coherence and intensity false colour composites



Input data: set of two Sentinel-1 SLCs

S1A_IW_SLC__1SDV_20151003T222043_20151003T222111_007994_00B2F6_4C0E.zip

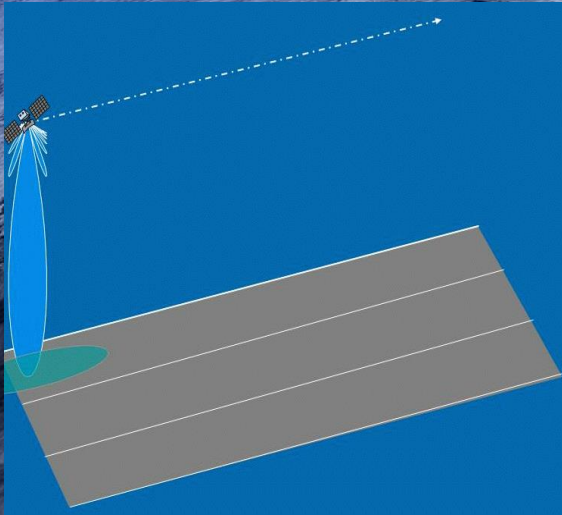
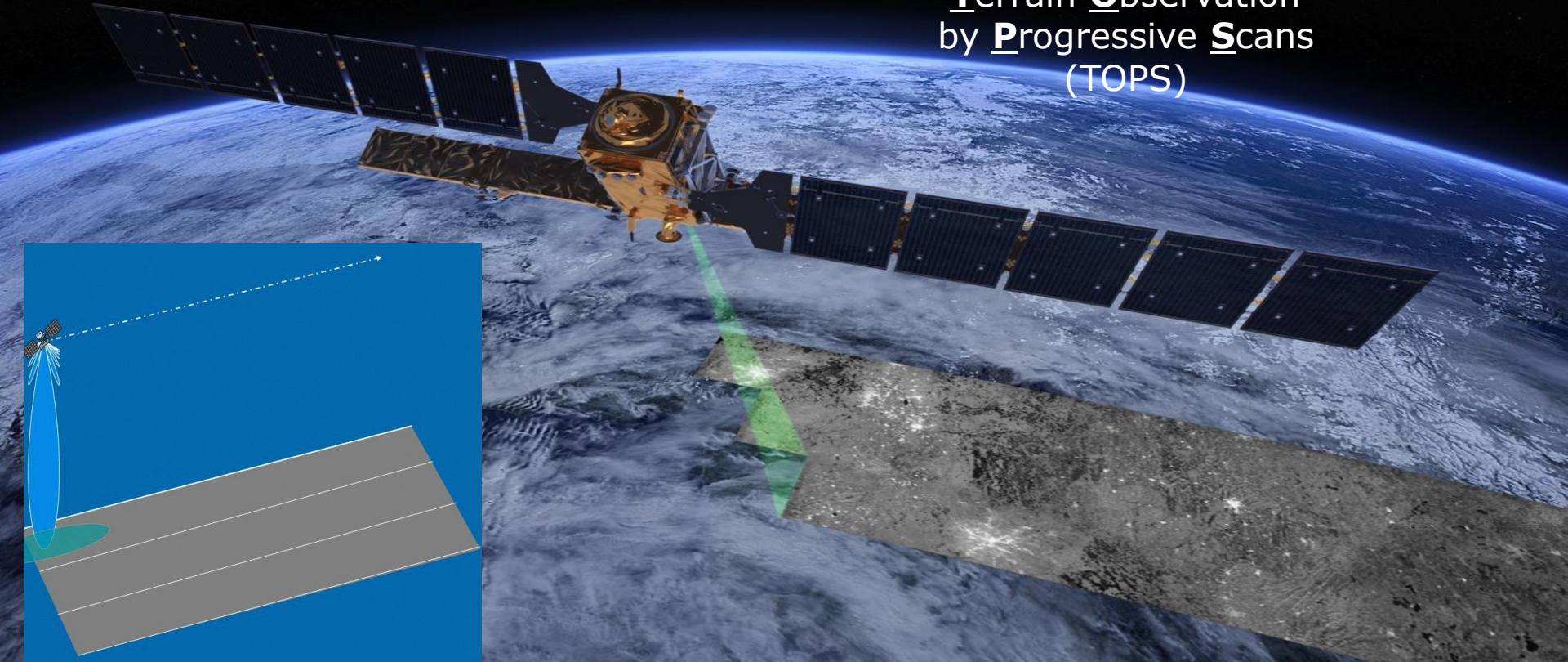
S1A_IW_SLC__1SDV_20171115T222013_20171115T222041_008298_00EAE8_F7A2.zip

Output: coherence – intensity false colour composites for land cover mapping and change detection

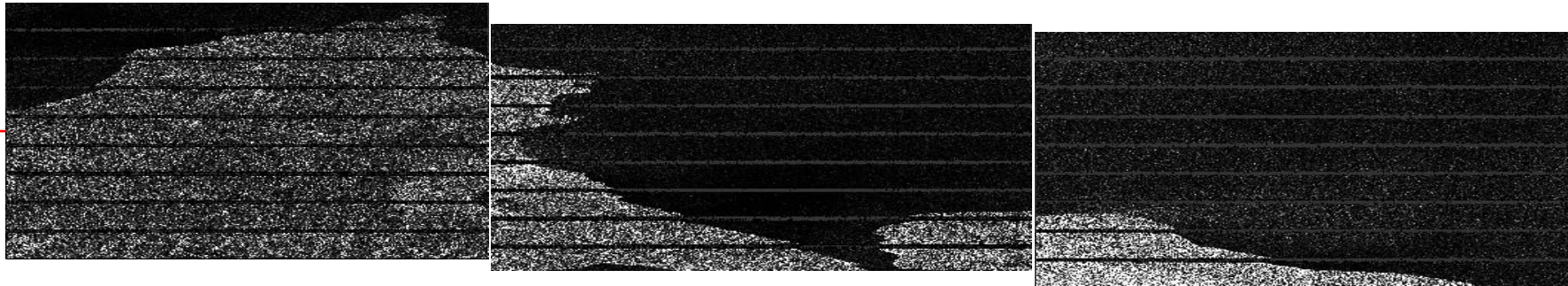
Sentinel-1 data acquisition



Terrain **O**bservation
by **P**rogressive **S**cans
(TOPS)

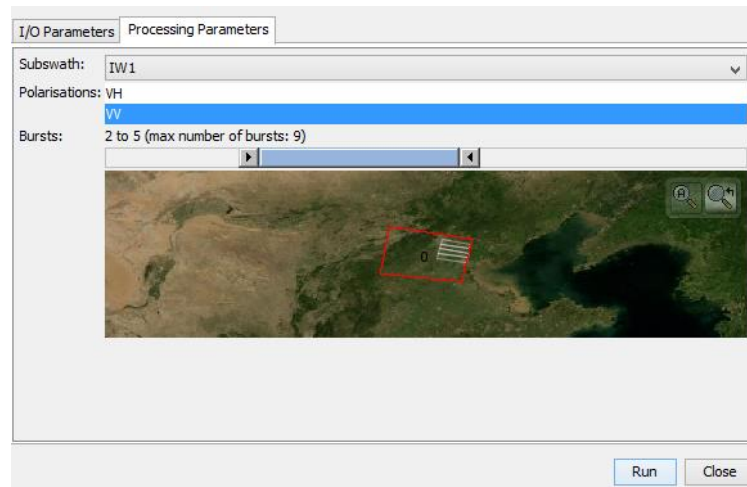
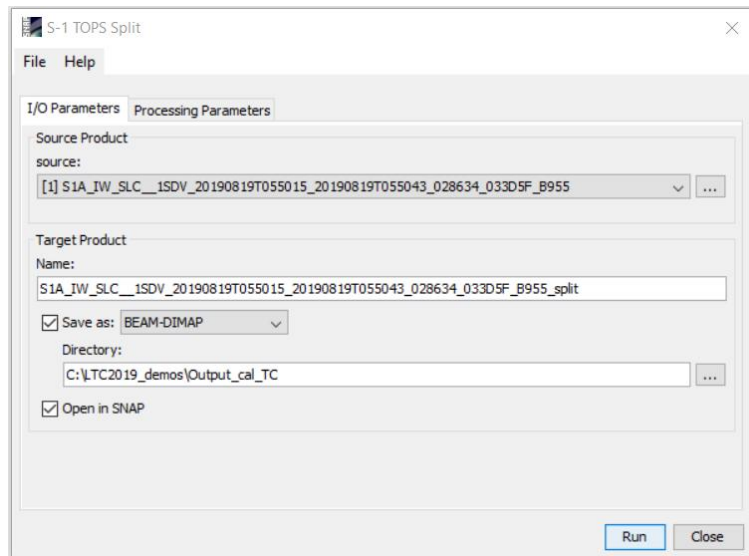


Bursted IW SLC



→ TOPSAR Split to choose a subswath and bursts for the AOI

Radar/Sentinel-1 TOPS/S-1 TOPS Split



- Selection of subswath
- Selection of polarization
- Selection of bursts

IW1
VV
2-5

TOPS Split applied to both S-1 SLCs

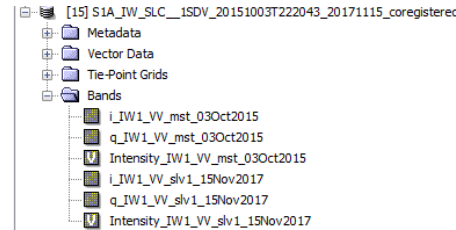
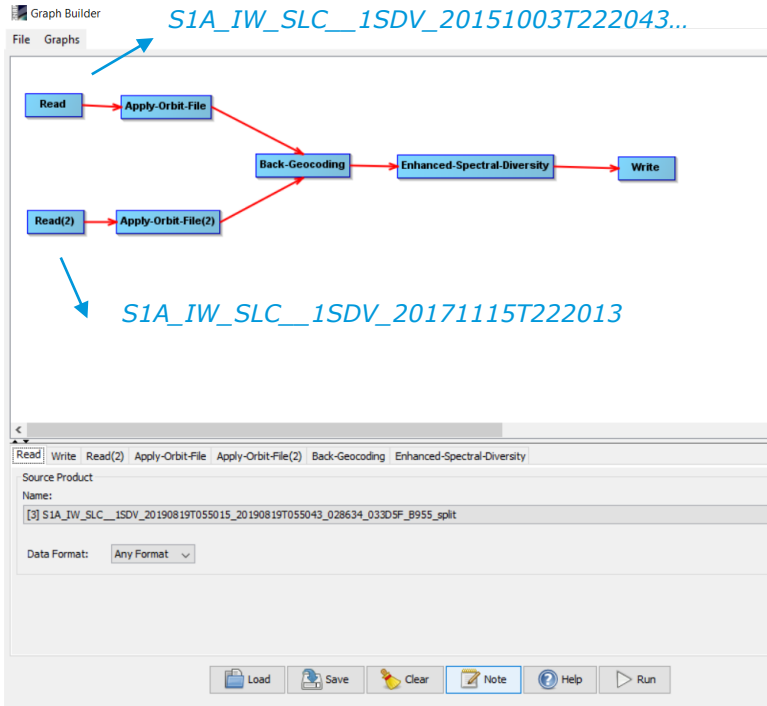


STEP 1

Interferometric Coherence



Coregistration



Coregistered bands in one product

Co-registration of two S-1 SLC split products (master and slave) of the same sub-swath using the orbits of the two products and a Digital Elevation Model (DEM).

ESD estimates the range and azimuth offset (exploiting the data at the overlapped area of the adjacent bursts) and performs range and azimuth corrections for every burst in the slave image



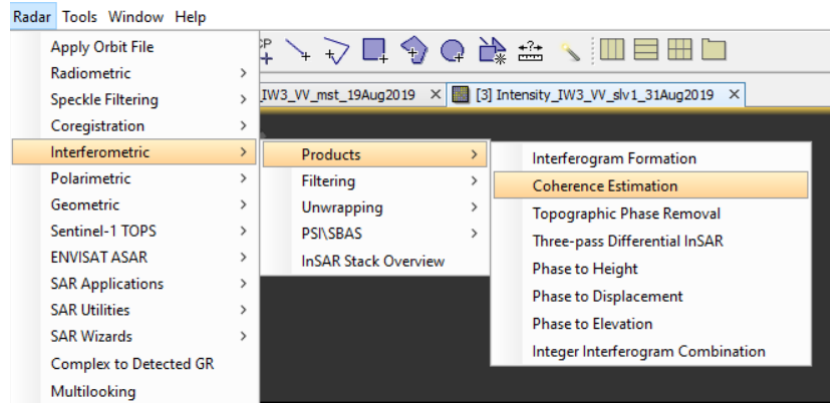
COHERENCE

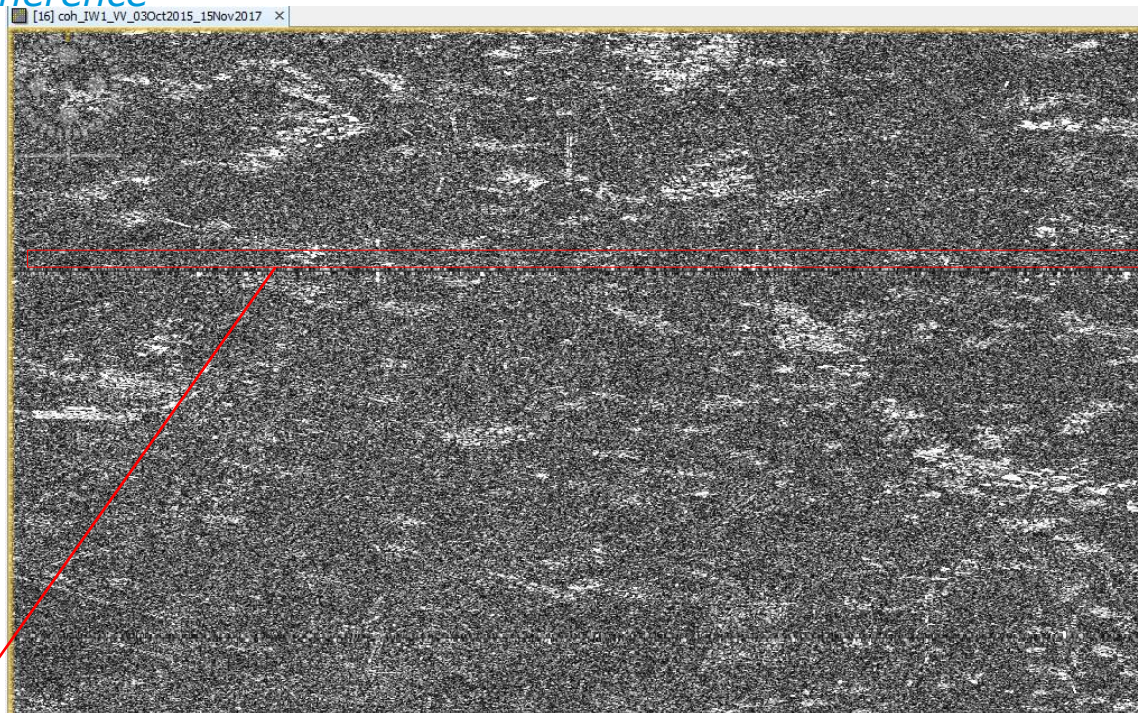
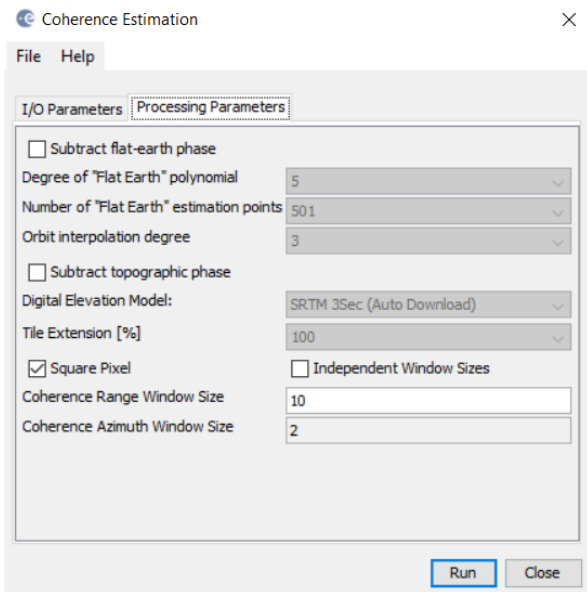
Measure of correlation between phase in two SAR complex images

Ranging from 0 (no correlation) to 1

Coherence may be affected by:

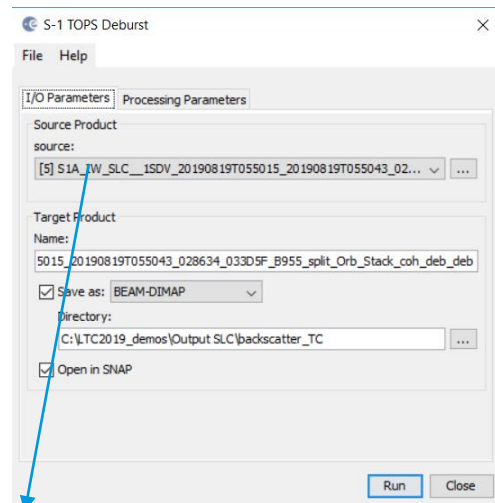
- Local slope
- Properties of the surface
- Time lag between acquisitions
- The perpendicular baseline
- Poor coregistration



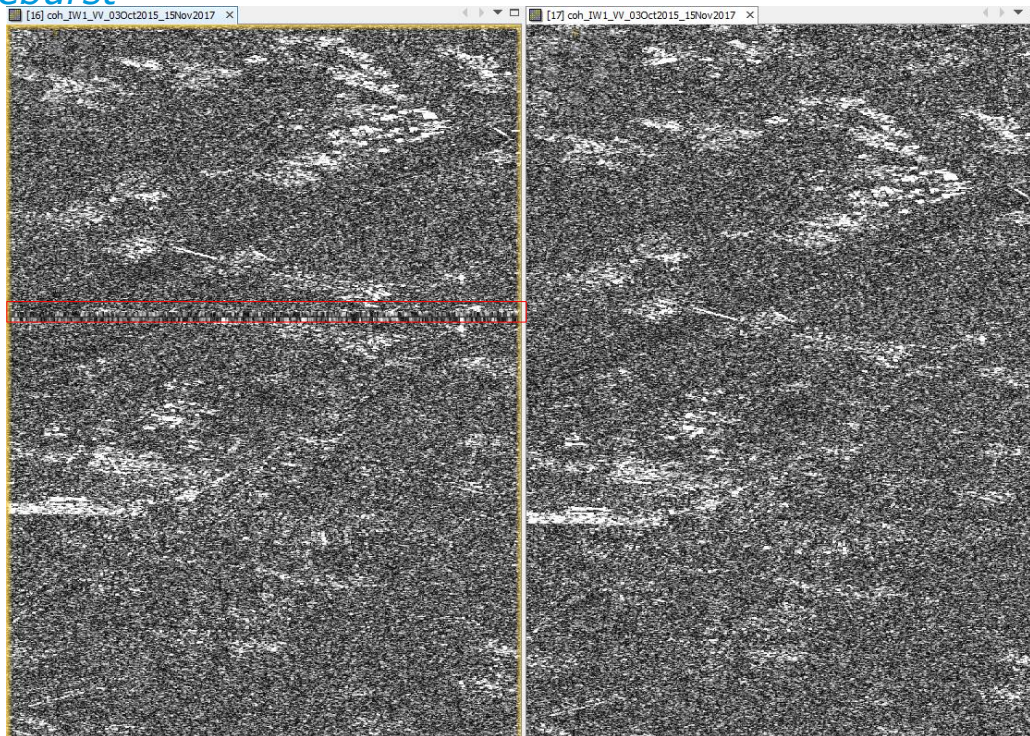


Demarcation black-filled line between bursts

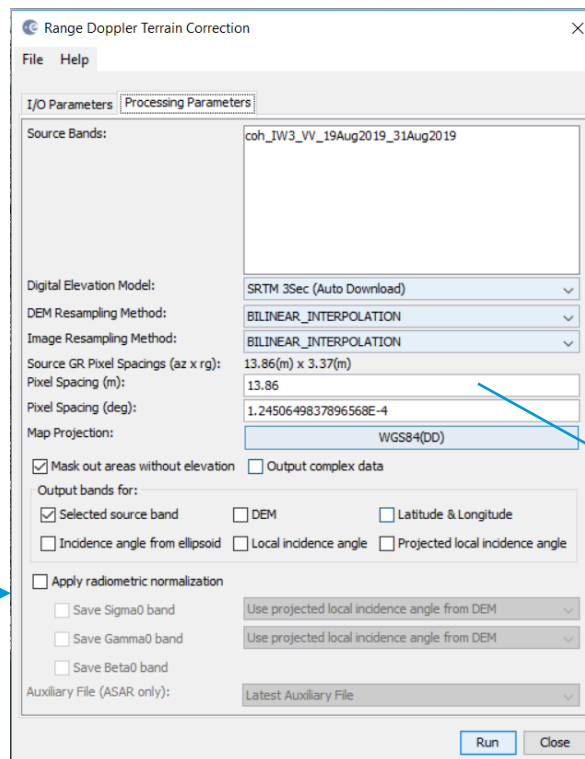
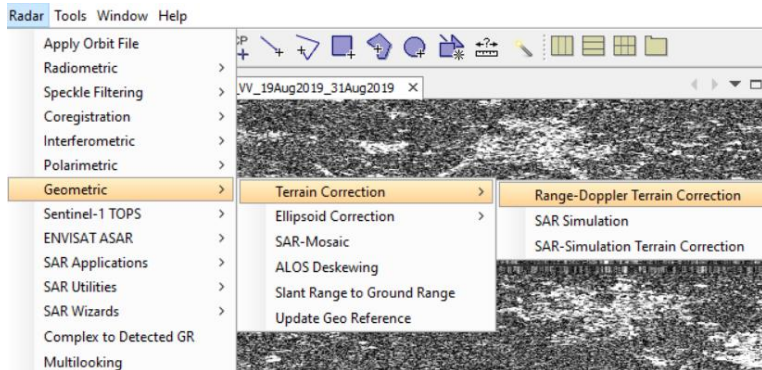
Radar/Sentinel-1 TOPS/S-1 TOPS Deburst



Input: Coherence



Terrain Correction



- Select:
- DEM
 - Resampling
 - Pixel spacing
 - Projection

Pixel spacing
20m

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

+ Geocoding





STEP 2

Backscatter Intensity

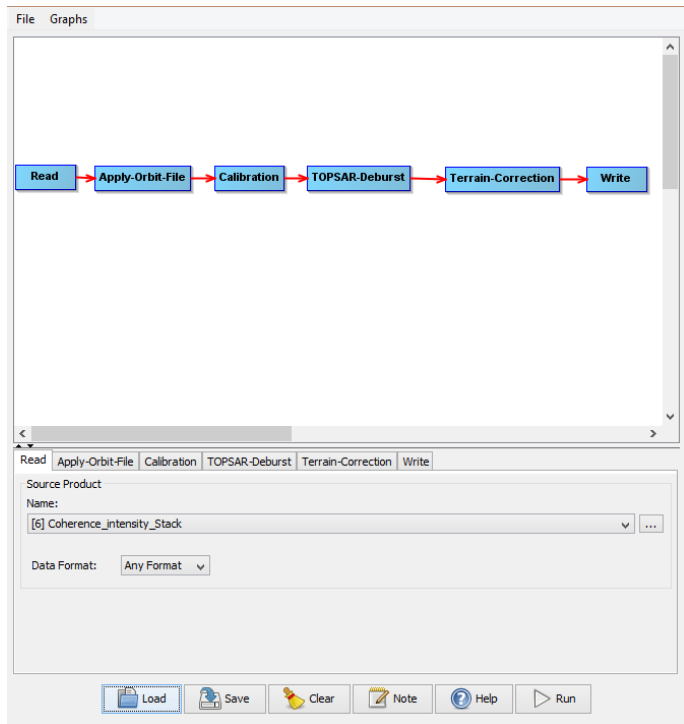


Backscatter Intensity product



MENU: *Graph Builder + Batch processing tool*

Input: Two splitted SLCs

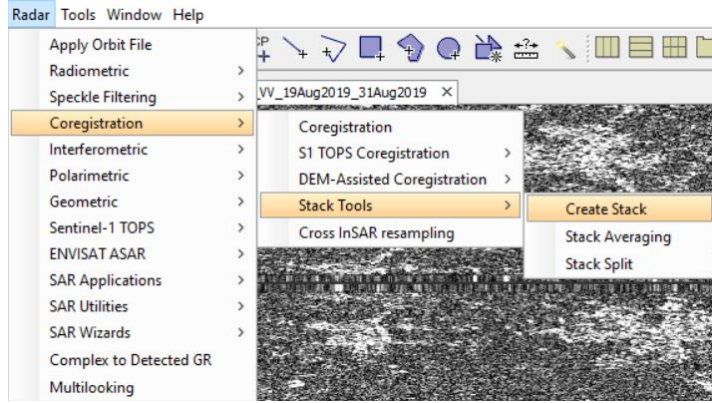


The screenshot shows the Batch processing tool interface. It features a table with columns: File Name, Type, Acquisition, Track, and Orbit. The table contains two rows of data. A red box highlights the 'Apply-Orbit-File' tab and the table. Another red box highlights the 'Load Graph' button. The interface also includes a 'Target Folder' section with a 'Save as:' dropdown set to 'BEAM-DIMAP' and a 'Directory:' field set to 'D:\DRAGON2019\Final Dataset\SLC_processed\backscatter_intensity'. There are checkboxes for 'Skip existing target files' and 'Keep source product name'. The bottom of the interface has buttons for 'Run remote', 'Load Graph', 'Run', 'Close', and 'Help'.

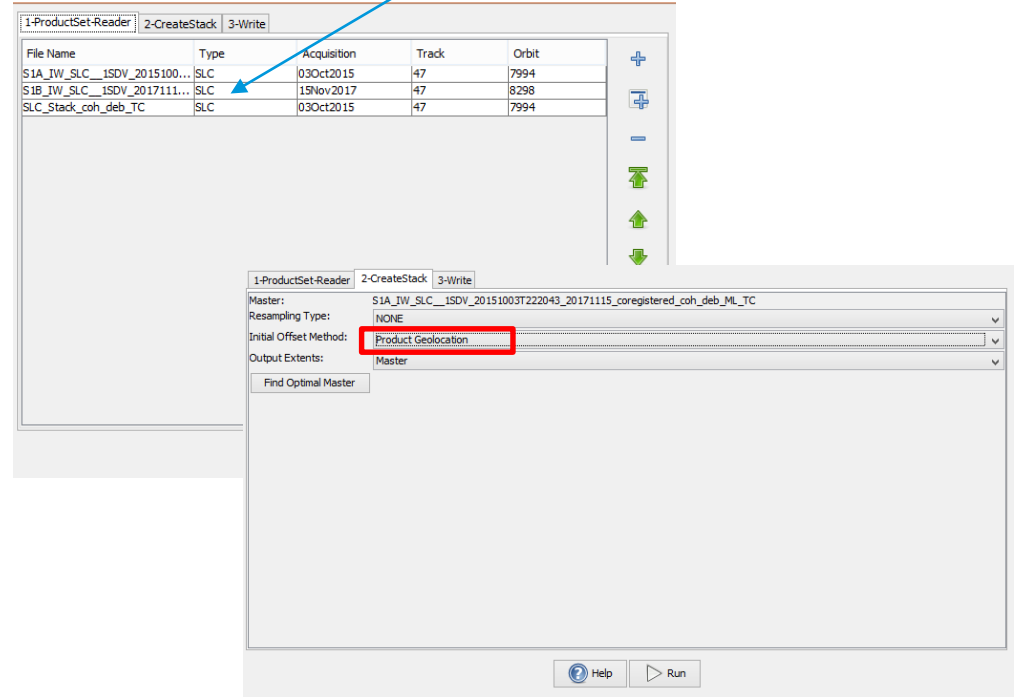
File Name	Type	Acquisition	Track	Orbit
S1A_IW_SLC__1SDV_20151...	SLC	03Oct2015	47	7994
S1B_IW_SLC__1SDV_20171...	SLC	15Nov2017	47	8298



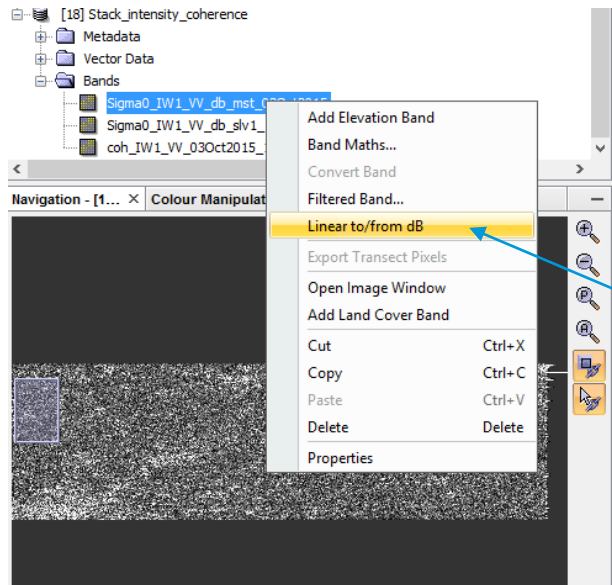
Creating a stack



Input: Coherence from STEP 1
Intensity backscatter for 2 SLCs from STEP 2



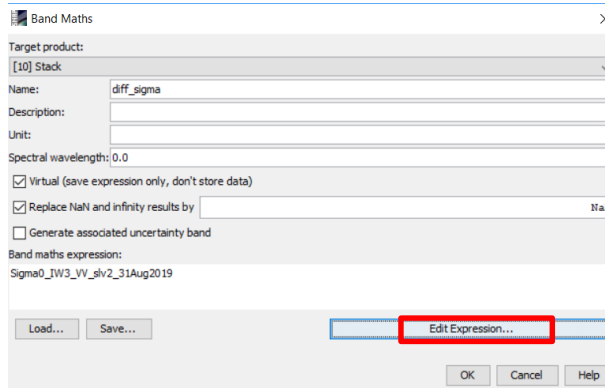
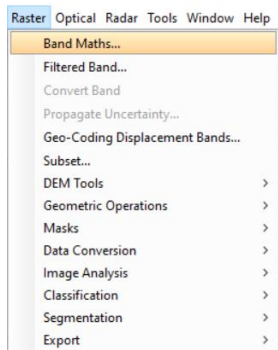
Conversion of sigma0 to db



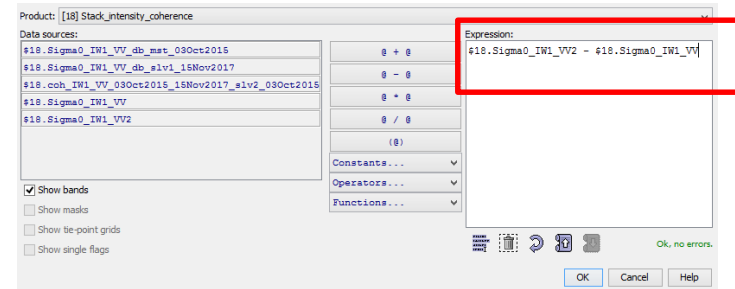
- Right click on the sigma0 band
- Conversion linear to/from db
- Right click on the sigma0_db virtual band
- Select „convert band”
- Save the product: File/Save product



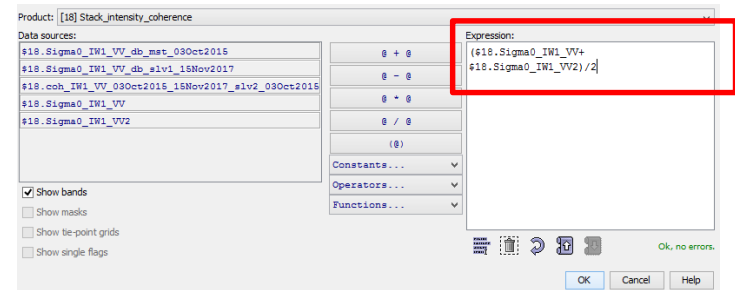
Band math: average sigma 0 and difference



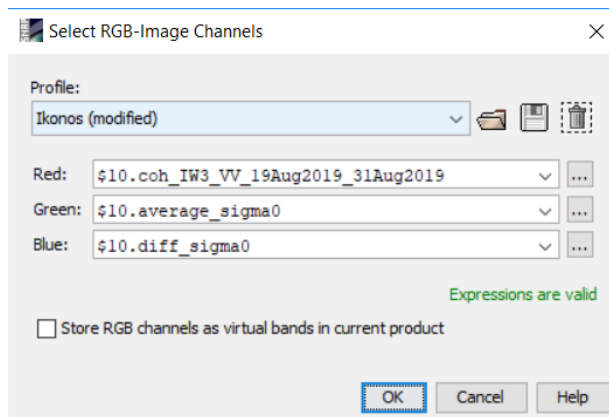
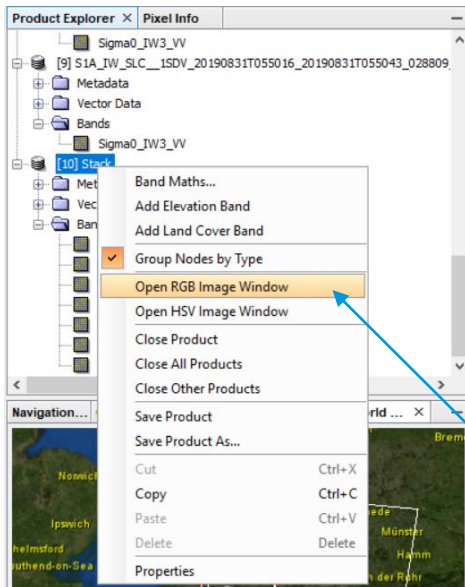
Sigma0 difference



Sigma0 average



Creating RGB false composite



Select RGB bands:

R: coherence

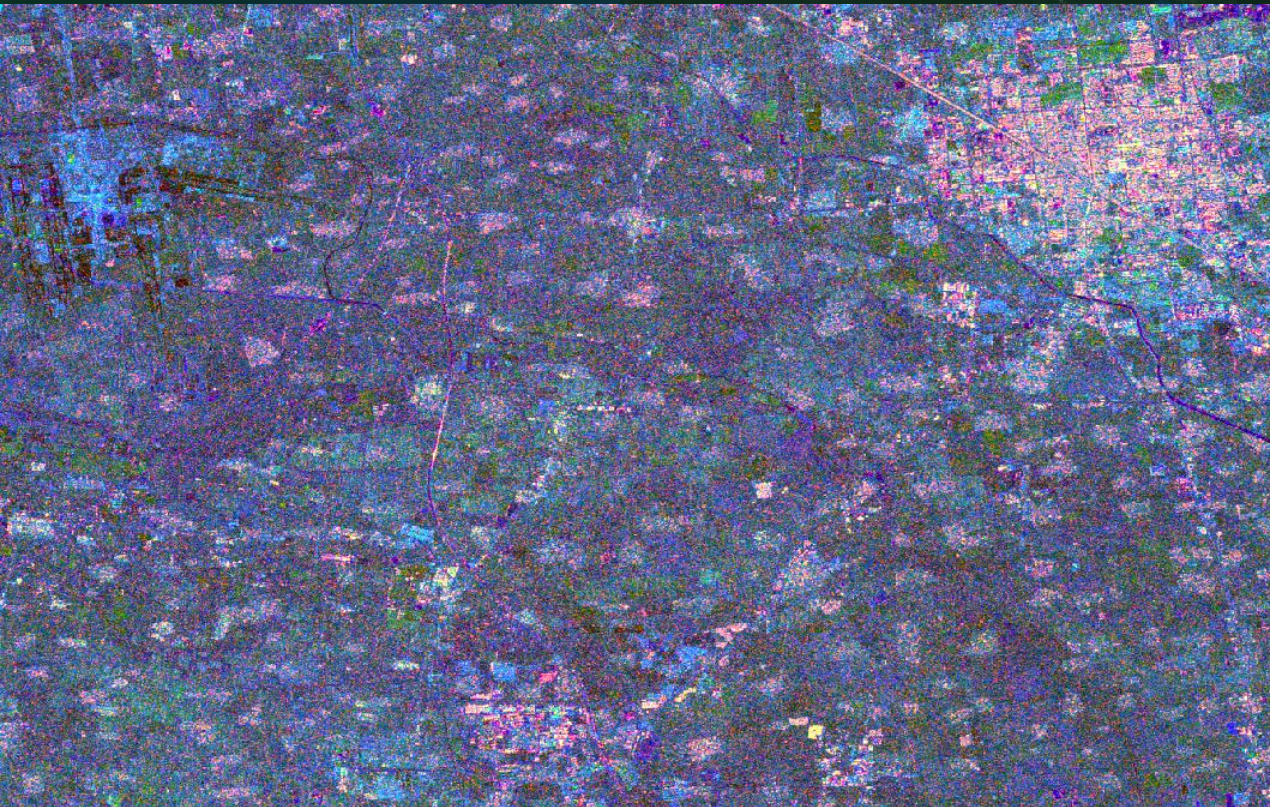
G: average sigma0

B: difference sigma0

- Right click on the stack product
- Open RGB Image Window



Resulting RGB false composite



Multi-temporal product (2015-2017)

Yellow: Urban centers

Magenta: objects not changing

Green: Vegetated lands and forests

Blue: objects that changed



