

# Introduction to ESA toolboxes

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**2019 ADVANCED INTERNATIONAL TRAINING COURSE IN LAND REMOTE SENSING** 中欧科技合作"龙计划"第四期 **2019**年陆地遥感高级培训班



## Introduction



Input data: set of Sentinel-1 SLCs

S1A\_IW\_SLC\_\_1SDV\_20190819T055015\_20190819T055043\_028634\_033D5F\_B955 S1A\_IW\_SLC\_\_1SDV\_20190831T055016\_20190831T055043\_028809\_03437F\_6942

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





## Sentinel-1 data acquisition



<u>T</u>errain <u>O</u>bservation by <u>P</u>rogressive <u>S</u>cans (TOPS)



#### Bursted IW SLC



TOPSAR Split to choose a subswath and bursts for the AOI



#### Scattering mechanisms







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## Sentinel-1 TOPSAR Split



S-1 TOPS Split X	S-1 TOPS Split	<
File Help	File Help	
I/O Parameters         Processing Parameters           Source Product         source:           [1] S1A_IW_SLC_1SDV_20190819T055015_20190819T055043_028634_033D5F_B955	I/O Parameters Processing Parameters           Subswath:         IW3         ~           Polarisations:         VH         ~	Selection of subswath
Target Product Name: S1A_IW_SLC1SDV_20190819T055015_20190819T055043_028634_033D5F_B955_split Save as: BEAM-DIMAP Oirectory: C:\LTC2019_demos\Output_cal_TC Open in SNAP	Bursts: 7 to 9 (max number of bursts: 9)	IW3 VV 7-9
Run Close	Run Close	

#### TOPS Split applied to both S-1 SLCs

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#### STEP 1 Interferometric Coherence



#### Coregistration



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azimuth corrections for every burst in the slave

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#### Coregistration





The Cross Correlation operator creates an alignment between master and slave images (matching automatically distributed correlation optimization windows between master and slave)

First on coarse level, with large windows and lower oversampling factors, later on fine level, with smaller windows and higher oversampling factors.

With the master-slave offsets computed, a coregistration polynomial (CPM) is estimated by the Warp operator, which resamples pixels in the slave image into pixels in the master image.



### Interferometric Coherence



#### 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

Rada	r Tools Window Help				
	Apply Orbit File		₽ `+ +> 🗖 🌗	Q Ì	≵ 🏤 🔨 💷 🖿 🖿 🗀
	Radiometric	>			
	Speckle Filtering	>	IW3_VV_mst_19Aug2019 >	< 🔳 [3	] Intensity_IW3_VV_slv1_31Aug2019 ×
	Coregistration	>			
	Interferometric	>	Products	>	Interferogram Formation
	Polarimetric	>	Filtering	>	Coherence Estimation
	Geometric	>	Unwrapping	>	Topographic Phase Removal
	Sentinel-1 TOPS	>	PSI\SBAS	>	Three-pass Differential InSAR
	ENVISAT ASAR	>	InSAR Stack Overvie	N	Phase to Height
	SAR Applications	>			Phase to Displacement
	SAR Utilities	>			Phase to Displacement
	SAR Wizards	>			Phase to Elevation
	Complex to Detected GR				Integer Interferogram Combination
	Multilooking				



#### Interferometric Coherence

Coherence Estimation	×
I/O Parameters Processing Parameters	
Subtract flat-earth phase	
Degree of "Flat Earth" polynomial	5 ~
Number of "Flat Earth" estimation points	501 🗸
Orbit interpolation degree	3 🗸
Subtract topographic phase	
Digital Elevation Model:	SRTM 3Sec (Auto Download) 🗸 🗸
Tile Extension [%]	100 🗸
Square Pixel	Independent Window Sizes
Coherence Range Window Size	10
Coherence Azimuth Window Size	2



Demarcation black-filled line between bursts

Close

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## S-1 TOPS Debursting



#### MENU: Radar/Sentinel-1 TOPS/S-1 TOPS Deburst

Ø Parameters         Ø Porcessing Parameters         Source Product         source:         [5] S1A_IW_SLCISDV_20190819T055015_20190819T055043_02          Target Product         Name:         5015_20190819T055043_028634_033D5F_B955_split_Orb_Stack_coh_deb_deb         Shve as:       BEAM-DIMAP         Directory:       C:\LTC2019_demos\Output SLC\backscatter_TC	O Parameters       Processing Parameters         Source Product          [5] S1A_IW_SLC_ISDV_20190819T055015_20190819T055043_02 v          Target Product          Name:          5015_20190819T055043_028634_033D5F_B955_split_Orb_Stack_coh_deb_deb          Seve as:       BEAM-DIMAP       v         Directory:        C:\LTC2019_demos\Output SLC\packscatter_TC          Open in SNAP	ile Help	
Source Product source: [5] S1A_IW_SLC1SDV_20190819T055015_20190819T055043_02 v Target Froduct Name: 5015_20190819T055043_028634_033D5F_B955_split_Orb_Stack_coh_deb_deb Source Product Source Product C:\LTC2019_demos\Output SLC\backscatter_TC	Source Product source: [5] S1A_TW_SLC1SDV_20190819T055015_20190819T055043_02 v Target Broduct Name: 5015_20190819T055043_028634_033D5F_B955_split_Orb_Stack_coh_deb_deb v Spive as:  BEAM-DIMAP v Directory: C:\LTC2019_demos\Output SLC\backscatter_TC v Open in SNAP	/O Parameters Processing Parameters	
[5] S1A_IW_SLC_1SDV_20190819T055015_20190819T055043_02 ↓ Target Froduct Name: 5015_20190819T055043_028634_033D5F_B955_split_Orb_Stack_coh_deb_deb Style as: BEAM-DIMAP ↓ Directory: C:\LTC2019_demos\Output SLC\backscatter_TC	[5] S1A_IW_SLC1SDV_20190819T055015_20190819T055043_02 ↓ Target Froduct Name: 5015_20190819T055043_028634_033D5F_B955_split_Orb_Stack_coh_deb_deb ✓ Save as: BEAM-DIMAP ↓ Directory: C:\LTC2019_demos\Output SLC\backscatter_TC ✓ Open in SNAP	Source Product source:	
Target Froduct Name: 5015 20 1908 197055043_028634_033D5F_B955_split_Orb_Stack_coh_deb_deb Seve as: BEAM-DIMAP V Directory: C:\LTC20 19_demos\Output SLC\backscatter_TC	Target Froduct Name: S015 20 1908 197055043_028634_033D5F_B955_split_Orb_Stack_coh_deb_deb Sove as: [BEAM-DIMAP Frectory: C:\LTC2019_demos\Output SLC\backscatter_TC Open in SNAP	[5] S1A_W_SLC1SDV_20190819T055015_20	0190819T055043_02 v
C: \LTC2019_demos\Output SLC\backscatter_TC	C:\LTC2019_demos\Output SLC\backscatter_TC	5015_20190819T055043_028634_033D5F_B953	5_split_Orb_Stack_coh_deb_deb
	Open in SNAP	C:\LTC2019_demos\Output SLC\backscatter	r_TC



#### Input: Coherence



## Terrain Correction



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

+ Geocoding

Range Doppler Terrain Correctio	on ×	
ile Help		
/O Parameters Processing Parameter	15	
iource Bands:	coh_IW3_VV_19Aug2019_31Aug2019	
Digital Elevation Model:	SRTM 3Sec (Auto Download) 🗸 🗸	
DEM Resampling Method:	BILINEAR_INTERPOLATION ~	
mage Resampling Method:	BILINEAR_INTERPOLATION ~	4
Source GR Pixel Spacings (az x rg): Pixel Spacing (m):	13.86(m) x 3.37(m) 13.86	
Pixel Spacing (deg):	1.2450649837896568E-4	
1ap Projection:	WGS84(DD)	
Mask out areas without elevation	Output complex data	
Selected source band	DEM Latitude & Longitude	
Incidence angle from ellipsoid	Local incidence angle         Projected local incidence angle	
Apply radiometric normalization		
Save Sigma0 band	Use projected local incidence angle from DEM $\qquad \bigtriangledown$	
Save Gamma0 band	Use projected local incidence angle from DEM $\qquad \bigtriangledown$	
Save Beta0 band		i i
Auxiliary File (ASAR only):	Latest Auxiliary File $\checkmark$	
	Run Close	

Select: > DEM > Resampling > Pixel spacing > Projection

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#### STEP 2 Backscatter Intensity



#### Backscatter Intensity product





#### Input: Two splitted SLCs Batch Processing : cal deb ML TC.xml $\times$ File Graphs I/O Parameters Apply-Orbit-File Calibration TOPSAR-Deburst Multilook Terrain-Correction File Name Type Acquisition Track Orbit S1A\_IW\_SLC\_\_1SDV\_20190... SLC 19Aug2019 37 28634 4 S1A\_IW\_SLC\_\_1SDV\_20190... SLC 37 28809 31Aug2019 ~ 1 Ŷ ⊵ B \* 2 Products Target Folder Save as: BEAM-DIMAP $\sim$ Directory: C:\LTC2019\_demos\Output SLC .... Skip existing target files 🗸 Keep source product name Load Graph Run Close Help

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#### Creating a stack



#### Input: Coherence from STEP 1 Radar Tools Window Help Intensity, backscatter for 2 SLCs from STEP 2 ↓ √ 🗖 🌒 🗣 🏠 🔧 🔲 🗏 🖿 🖿 Apply Orbit File P+ Create Stack Radiometric 3 1-ProductSet-Reader 2-CreateStack 3-Write VV\_19Aug2019\_31Aug2019 × Speckle Filtering 3 File Name Type Acquisition Track Orbit ÷ Coregistration > Coregistration S1A IW SLC 1SDV 2019081... SLC 19Aug2019 37 28634 S1A\_IW\_SLC\_\_1SDV\_2019083... SLC 37 28809 31Aug2019 Interferometric > S1 TOPS Coregistration 규 S1A\_IW\_SLC\_\_1SDV\_2019081... SLC 28634 19Aug2019 Polarimetric 5 **DEM-Assisted Coregistration** Geometric Stack Tools > Create Stack Sentinel-1 TOPS Cross InSAR resampling Stack Averaging ENVISAT ASAR Create Stack Х Stack Split SAR Applications 1-ProductSet-Reader 2-CreateStack 3-Write SAR Utilities Master: S1A\_IW\_SLC\_\_1SDV\_20190819T055015\_20190819T055043\_028634\_033D5F\_B955\_split SAR Wizards Resampling Type: NONE Initial Offset Method: Product Geolocation Complex to Detected GR Output Extents: Master Multilooking Find Optimal Master

🕜 Help 🛛 🕞 Run



## 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

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# Band math: average sigma 0 and difference

Band Maths			
Filtered Band		Target product:	
		[10] Stack	
Convert Band		Name:	diff_sigma
Propagate Uncertainty		Description:	
Geo-Coding Displacement Bar	nds	Unit:	
Subset		Spectral wavele	ngth: 0.0
DEM Tools	>	Virtual (sav	e expression only, don't stor
Geometric Operations	>	Replace Na	N and infinity results by
Masks	>		
Data Conversion	>	Generate a	ssociated uncertainty band
mage Analysis	>	Band maths exp	vression:
Classification	>	Siginao_1443_4	*_avz_51Adg2015
Segmentation	>		
Export	>	Load	Save

Target product:			
[10] Stack			
Name:	diff_sigma		
Description:			
Unit:			
Spectral waveler	ngth: 0.0		
Virtual (save	e expression only, don't store	a)	
Replace Nat	N and infinity results by		Na
Generate as	sociated uncertainty band		
Band maths exp	ression:		
Sigma0_IW3_V\	/_slv2_31Aug2019		
Load	Save	Edit	Expression

Band Maths Expression Editor	Sigma	0 difference x
Product: [10] Stack		$\sim$
Data sources:		Expression:
\$10.coh_IW3_VV_19Aug2019_31Aug2019	0 + 0	\$10.Sigma0_IW3_VV_slv1_19Aug2019_db-
<pre>\$10.Sigma0_IW3_VV_slv1_19Aug2019</pre>	0 - 0	\$10.Sigma0_IW3_VV_s1v2_31Aug2019_db
<pre>\$10.Sigma0_IW3_VV_slv2_31Aug2019</pre>		
<pre>\$10.Sigma0_IW3_VV_slv1_19Aug2019_db</pre>	6 * 6	
<pre>\$10.Sigma0_IW3_VV_slv2_31Aug2019_db</pre>	0 / 0	
<pre>\$10.average_sigma0</pre>	(8)	
\$10.diff_sigma0	Constants	
	constants v	-
Show bands	Operators V	-
Show masks	Functions V	
Show tie-point grids		
Show single flags		Ck, no errors.
		OK Cancel Help

#### Sigma0 average

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Product: [10] Stack										
Data sources:			Expres	sion:						
\$10.coh_IW3_VV_19Aug2019_31Aug2019	0 + 0		(\$10	.Sigm	a0_IW	3_VV	slvl	19Aug2	019_db+	F
<pre>\$10.Sigma0_IW3_VV_slv1_19Aug2019</pre>	8 - 8		\$10.	Sigma	0_IW3	_VV_	slv2_3	1Aug20	19_db)/	2
\$10.Sigma0_IW3_VV_slv2_31Aug2019		-								
<pre>\$10.Sigma0_IW3_VV_slv1_19Aug2019_db</pre>	0 * 0		-							-
\$10.Sigma0_IW3_VV_slv2_31Aug2019_db	0 / 0									
\$10.average_sigma0	(8)									
\$10.diff_sigma0	Constants	~								
Show bands	Operators	~								
Show masks	Functions	~								
Show tie-point grids				11411	-		-			_
Show single flags			100		Q	10	20		Ok, no e	errors.



## Creating RGB false composite



Profile: Ikonos (modified)	Selec	t RGB-Image Channels X	
Ikonos (modified)       Image: Second structure         Red:       \$10.coh_IW3_VV_19Aug2019_31Aug2019       Image: Second structure         Green:       \$10.average_sigma0       Image: Second structure         Blue:       \$10.diff_sigma0       Image: Second structure         Expressions are valid       Image: Store RGB channels as virtual bands in current product	Profile:		
Red:       \$10.coh_IW3_VV_19Aug2019_31Aug2019          Green:       \$10.average_sigma0          Blue:       \$10.diff_sigma0          Expressions are valid          Store RGB channels as virtual bands in current product	Ikonos	(modified) - v 🔁 🛄 📋	Se
Expressions are valid Store RGB channels as virtual bands in current product	Red: Green: Blue:	\$10.coh_IW3_VV_19Aug2019_31Aug2019          \$10.average_sigma0          \$10.diff_sigma0	R: G:
Cancel Trap	Stor	Expressions are valid re RGB channels as virtual bands in current product OK Cancel Help	D.

Select RGB bands:

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R: coherence G: average sigma0 B: difference sigma0

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Right click on the stack productOpen RGB Image Window



### Resulting RGB false composite



Multi-temporal 12-day product (August 2019)

Yellow: Urban centers Magenta: objects not changing Green: Vegetated lands and forests Blue: objects changing in 12 days (e.g. ploughing)

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#### 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

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#### Answers to your questions



What is the difference between Range Doppler TC and SAR Simulated TC?

SAR Simulation TC : generates simulated SAR image using DEM and orbit vectors from orginal file, coregisters the simulated SAR image and original one, terrain correct – for each pixel of DEM finding corresponding position in the simulated image and corresponding pxel position in the original SAR image

The Range Doppler Terrain Correction Operator implements the Range Doppler orthorectification. It uses: orbit state vector information in the metadata, the radar timing annotations, the slant to ground range conversion parameters together with the reference DEM data to derive the precise geolocation information.





What do we do if my AOI is in two products?



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