

Sentinel-1 Radiometric and Geometric Calibration

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■ Introduction




- The Sentinel-1 Mission Performance Centre and their Expert Support Laboratories are responsible for quality assessment and calibration of all S1 products.
- This is achieved through continual monitoring of the instrument performance and product quality & calibration.
- Improvements are being continually made to improve product performance and hence providing an improving service for the EU Copernicus Program user community.
- This presentation gives an overview of the MPC Radiometric and Geometric Calibration of S1 products.

Overall Approach

• A variety of point targets are used for S1 radiometric and geometric calibration:

	IRF Parameters	Co-registration	Azimuth Ambiguities	Cross-Talk	Polarimetric Calibration	Radiometric Calibration	Geometric Calibration
	✓	✓	✓	✗	✓	✓	
DLR Transponders							
	✓	✗		✓	✗	✓	
DLR Corner Reflectors							
	✓	✗		✓	✗	✓	
BAE Corner Reflector							

Overall Approach

	IRF Parameters	Co-registration	Azimuth Ambiguities	Cross-Talk	Polarimetric Calibration	Radiometric Calibration	Geometric Calibration
		✗	✗	✗	✗	✓	✓
Surat Corner Reflectors							
		✗	✗	✗	✗		✓
UZH Corner Reflectors							
		✗			✗		✓
Rosamond Corners							

A blank square indicates that the PT could be used but is not routinely by the MPC.

Overall Approach

- Distributed targets are also used:

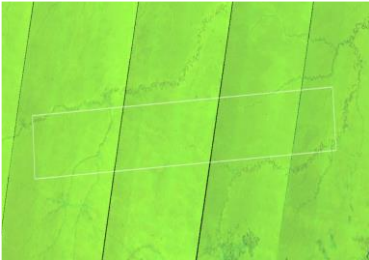



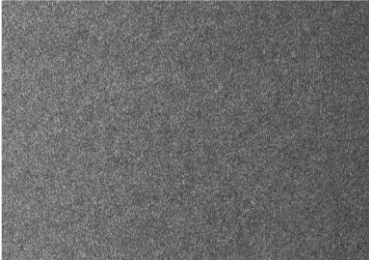



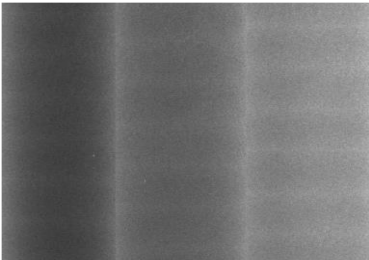



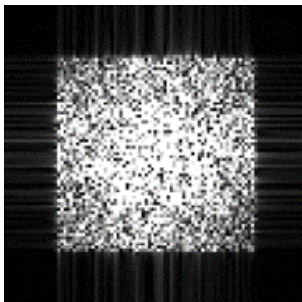
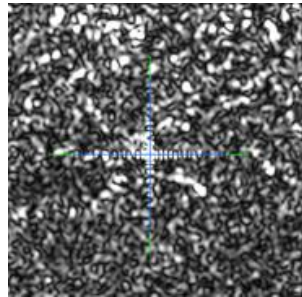
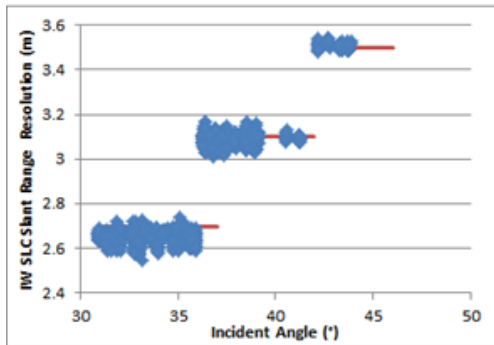
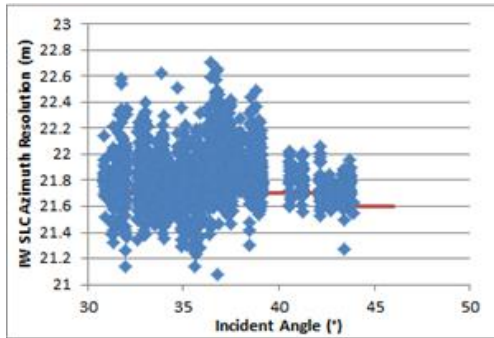
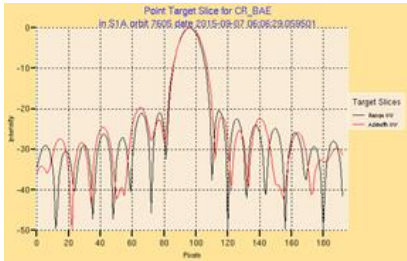
	Elevation Antenna Patterns	Equivalent Number of Looks	NESZ
			
Amazon Rainforest			
			
Uniform Ocean Scenes			
			
Low Backscatter Scenes			

Image Quality

IRF Parameters



Mode/Swath	Azimuth Spatial Resolution (m)	Slant Range Spatial Resolution (m)
S1A IW1	21.79±0.20	2.65±0.03
S1A IW2	21.92±0.21	3.09±0.02
S1A IW3	21.73±0.10	3.51±0.01

Mode/Swath	Azimuth Spatial Resolution (m)	Slant Range Spatial Resolution (m)
S1B IW1	21.86±0.21	2.65±0.03
S1B IW2	21.95±0.22	3.09±0.02
S1B IW3	21.71±0.08	3.51±0.01

Satellite/Mode	Integrated Sidelobe Ratio (dB)	Range ISLR (dB)	Azimuth ISLR (dB)	Peak Sidelobe Ratio (dB)	Spurious Sidelobe Ratio (dB)
S-1A IW	-10.86±3.30	-15.65±1.39	-16.23±1.56	-19.53±1.20	-22.68±3.44
S-1B IW	-10.95±3.33	-15.60±1.33	-16.45±1.60	-19.76±1.27	-23.05±3.47

Image Quality

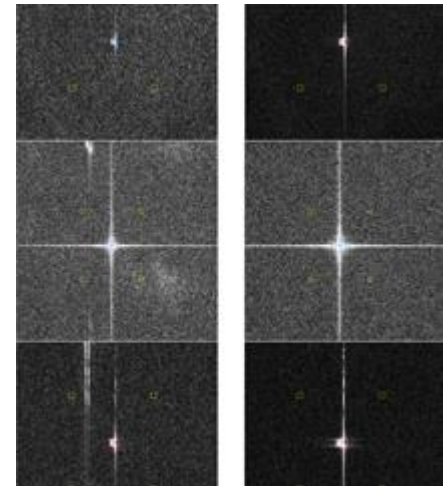
Co-registration

Satellite/Mode	Range Co-registration Accuracy (m)	Azimuth Co-registration Accuracy (m)
S-1A IW	0.02±0.08	0.05±0.29
S-1B IW	0.01±0.04	0.07±0.35

IRF peak measured to 1/8 pixel.

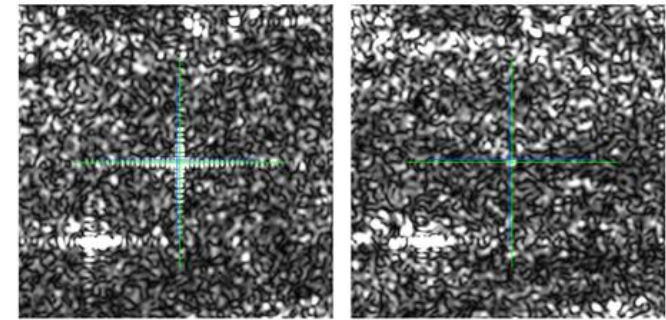
Azimuth Ambiguities

Satellite/Mode	Early Azimuth Ambiguity Ratio (dB)	Late Azimuth Ambiguity Ratio (dB)
S-1A IW	-27.33±2.34	-29.26±2.87
S-1B IW	-28.49±3.18	-27.35±1.92



Cross-Talk

Satellite	Corner Reflector Cross-talk (dB)
S-1A	-37.5±4.2
S-1B	-40.8±5.1



DLR CR D38 (IW SLC HH) DLR CR D38 (IW SLC HV)

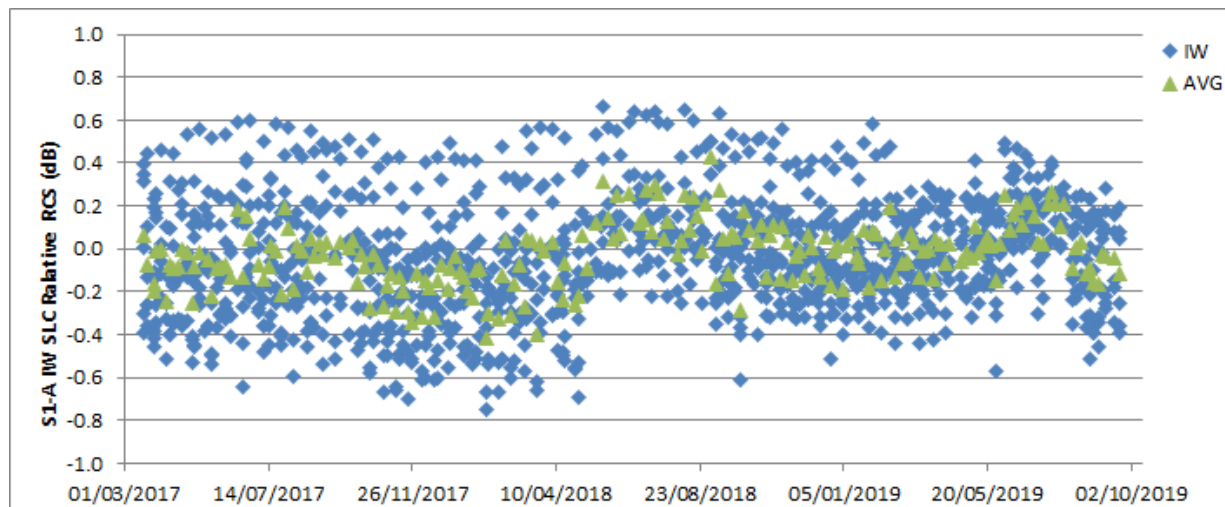
Radiometric Calibration

Radiometric Calibration

Satellite/Mode	All	VH	VV
S-1A IW	-0.02±0.22	-0.04±0.24	0.07±0.19
S-1B IW	-0.14±0.24	-0.25±0.24	-0.03±0.19

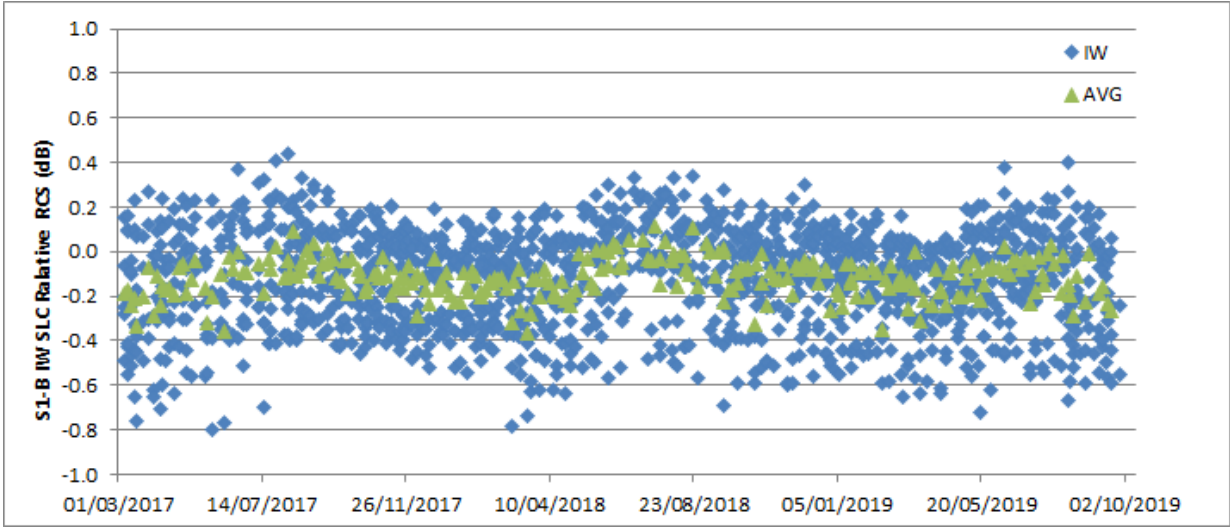
Satellite/Polarisation	IW1	IW2	IW3
S-1A VH	-0.11±0.22	0.04±0.27	0.02±0.25
S-1A VV	0.04±0.18	0.16±0.12	0.06±0.24
S-1B VH	-0.28±0.19	-0.31±0.27	-0.15±0.28
S-1B VV	-0.02±0.18	-0.07±0.16	-0.03±0.22

DLR transponder & IPF v3.1



Radiometric Calibration

Radiometric Calibration



BAE CR

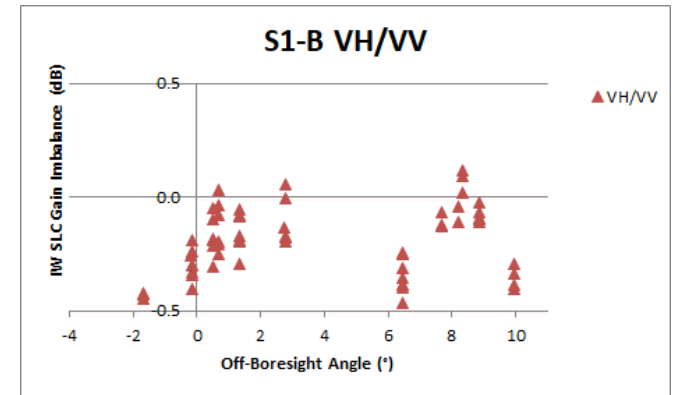
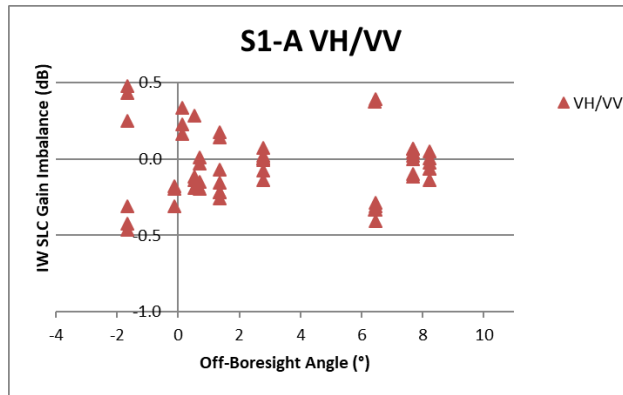
S-1A IW	S-1B IW
-0.19±0.21	-0.23±0.19

Surat CRs

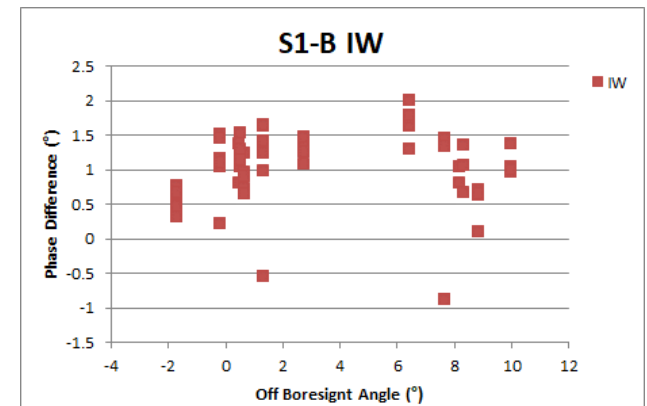
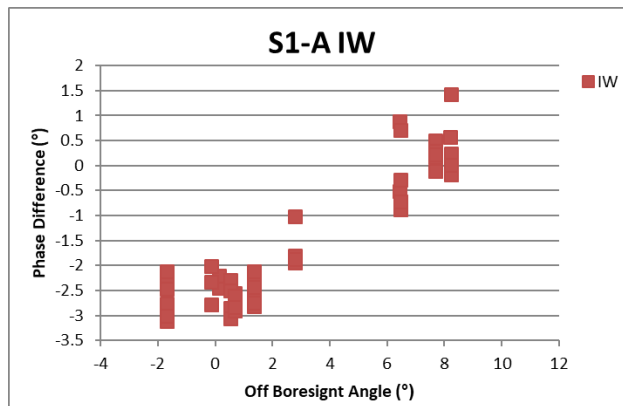
Satellite	All	IW1 HH	IW2 HH
S-1A	0.20±0.54	0.18±0.45	0.24±0.65
S-1B	0.06±0.55	0.10±0.49	-0.01±0.63

Radiometric Calibration

Polarimetric Calibration



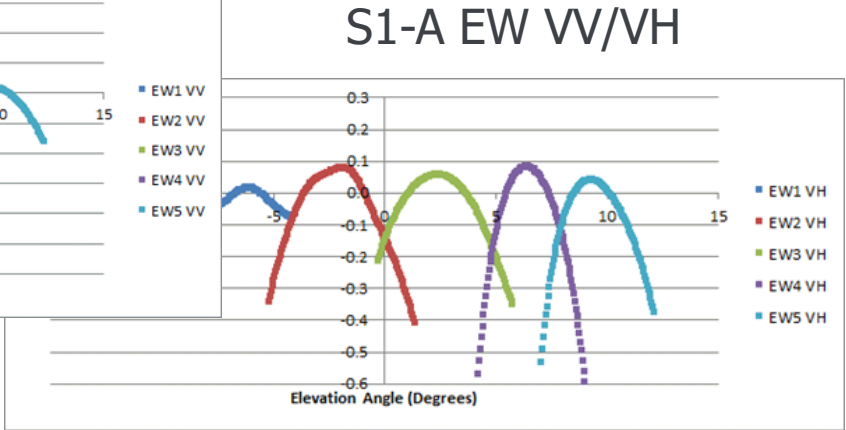
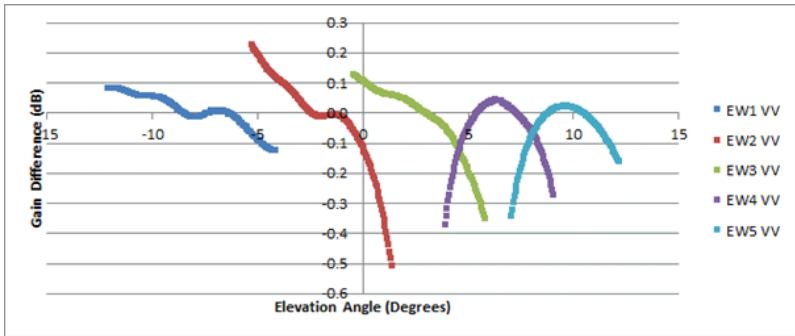
Satellite/Mode	Gain Imbalance (dB)
S-1A IW (VV/VH)	-0.05±0.22
S-1B IW (VV/VH)	-0.22±0.16



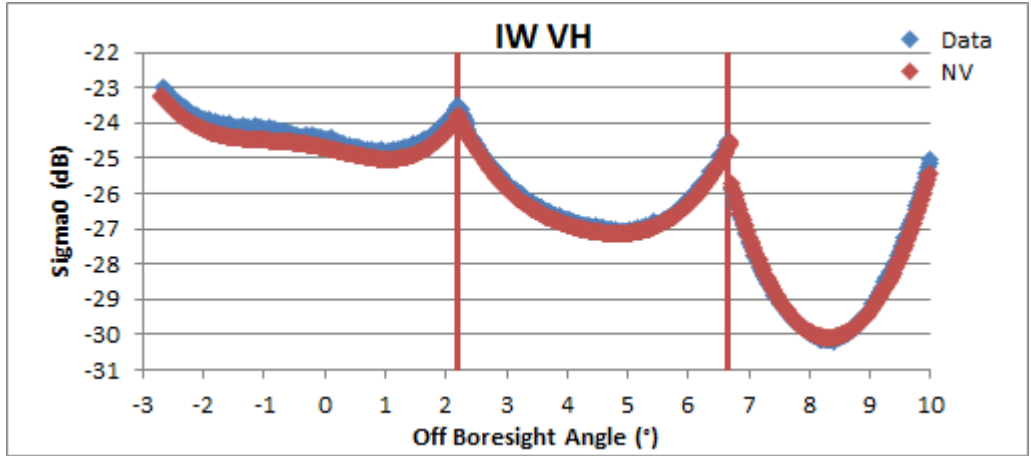
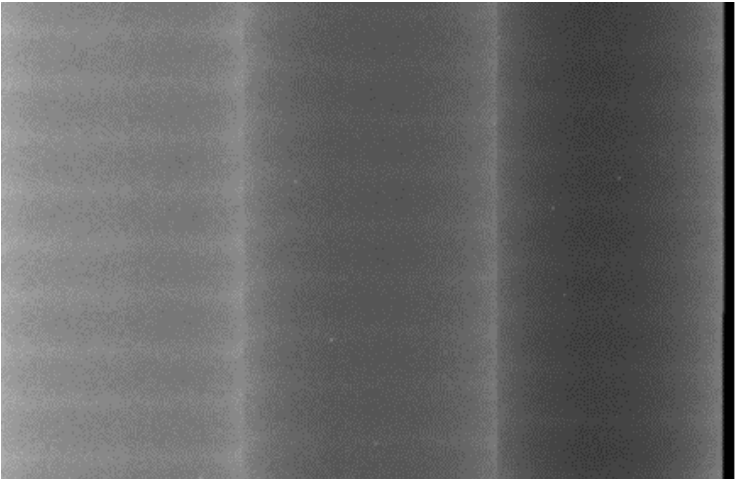
Satellite/Mode	Phase Difference (°)
S-1A IW	-1.49±1.31
S-1B IW	1.05±0.52

Radiometric Calibration

Radiometric Calibration



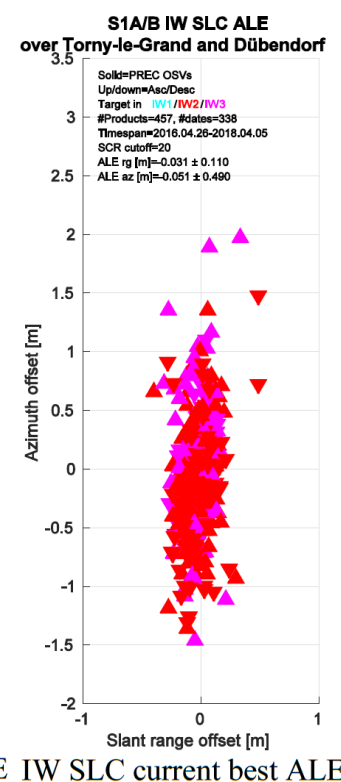
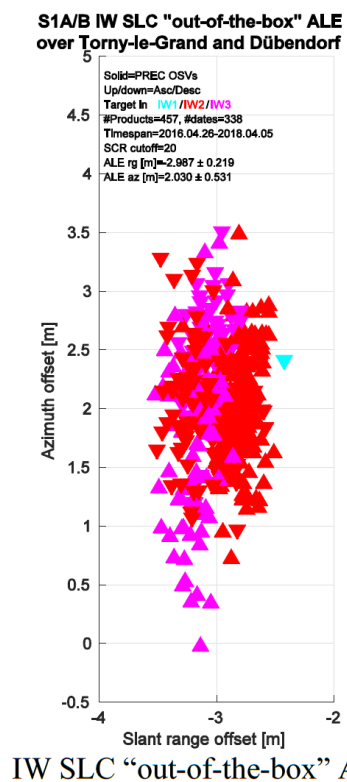
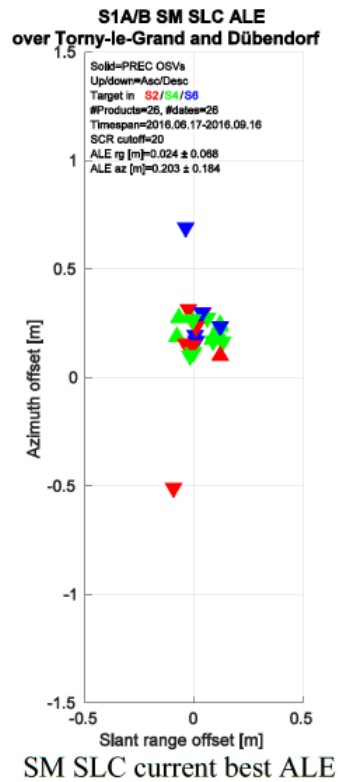
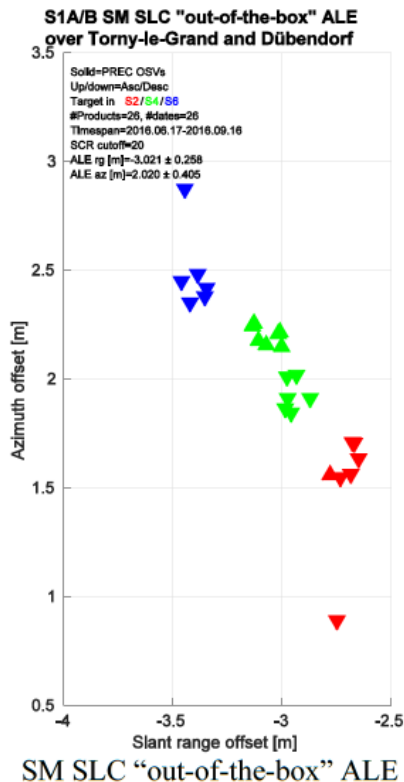
Satellite/Product Type	IW1	IW2	IW3
S-1A GRDH	4.71, 1.65	4.60, 1.66	4.51, 1.68
S-1B GRDH	4.70, 1.65	4.57, 1.67	4.51, 1.68



Geometric Calibration

Geometric Calibration

- Out-of-the-box absolute localisation error (ALE) based on delivered products without additional post-processing.
- Best ALE includes corrections such as atmospheric path delay, solid Earth Tides, geodetic frame shift and timing biases.

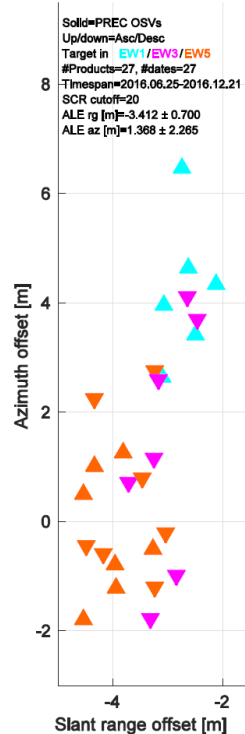


Geometric Calibration

Geometric Calibration

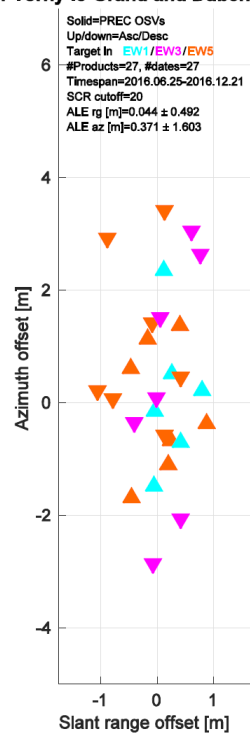
- Out-of-the-box absolute localisation error (ALE) based on delivered products without additional post-processing.
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S1A/B EW SLC "out-of-the-box" ALE over Torony-le-Grand and Dübendorf



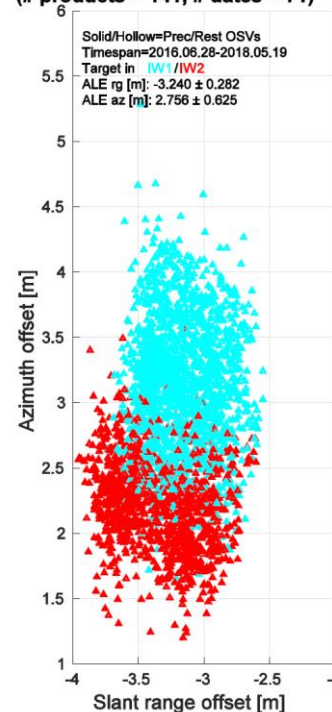
EW SLC "out-of-the-box" ALE

S1A/B EW SLC ALE over Torony-le-Grand and Dübendorf



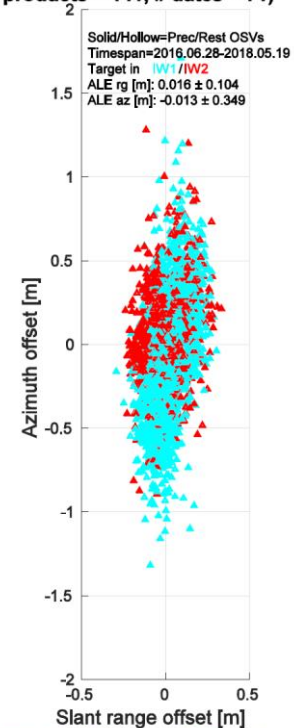
EW SLC current best ALE

S1A/B IW SLC "out-of-the-box" ALE over Surat array (# products = 141, # dates = 71)



IW SLC "out-of-the-box" ALE

S1A/B IW SLC ALE over Surat array (# products = 141, # dates = 71)



IW SLC best ALE estimate

Geometric Calibration

Geometric Calibration

- Out-of-the-box absolute localisation error (ALE) based on delivered products without additional post-processing.
- Best ALE includes corrections such as atmospheric path delay, solid Earth Tides, geodetic frame shift and timing biases.

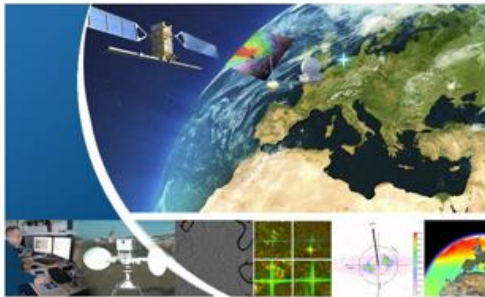
Mode	Geolocation Accuracy Requirement (3σ)	Dimension	“Out-of-the-box” ALE (m)	ALE after post-processing corrections (m)
SM	2.5m	Range	-3.02 ± 0.26	0.02 ± 0.07
		Azimuth	2.02 ± 0.41	0.20 ± 0.18
IW	7m	Range	-2.99 ± 0.22	-0.03 ± 0.11
		Azimuth	2.03 ± 0.52	0.05 ± 0.49
EW	Unspecified	Range	-3.41 ± 0.70	0.04 ± 0.49
		Azimuth	1.37 ± 2.27	0.37 ± 1.60

Other Information

- N-Cyclic Reports, Annual Performance Report & Tech Notes.



S-1 MPC



S1-A N-Cyclic Performance Report - 2019-06
Cycles 181 to 184 (21-Sep-2019 to 08-Nov-2019)

Reference: MPC-0100
 Nomenclature: DI-MPC-NPR
 Issue: 2019-06. 1
 Date: 2019, Nov. 07



Copernicus

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 The views expressed on this document are those of the authors and do not necessarily represent those of the European Commission.

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S-1 MPC

S-1A & S-1B Annual Performance Report for 2018

Reference: MPC-0436
 Nomenclature: DI-MPC-APR
 Issue: 1,1
 Date: 2019, Mar. 15

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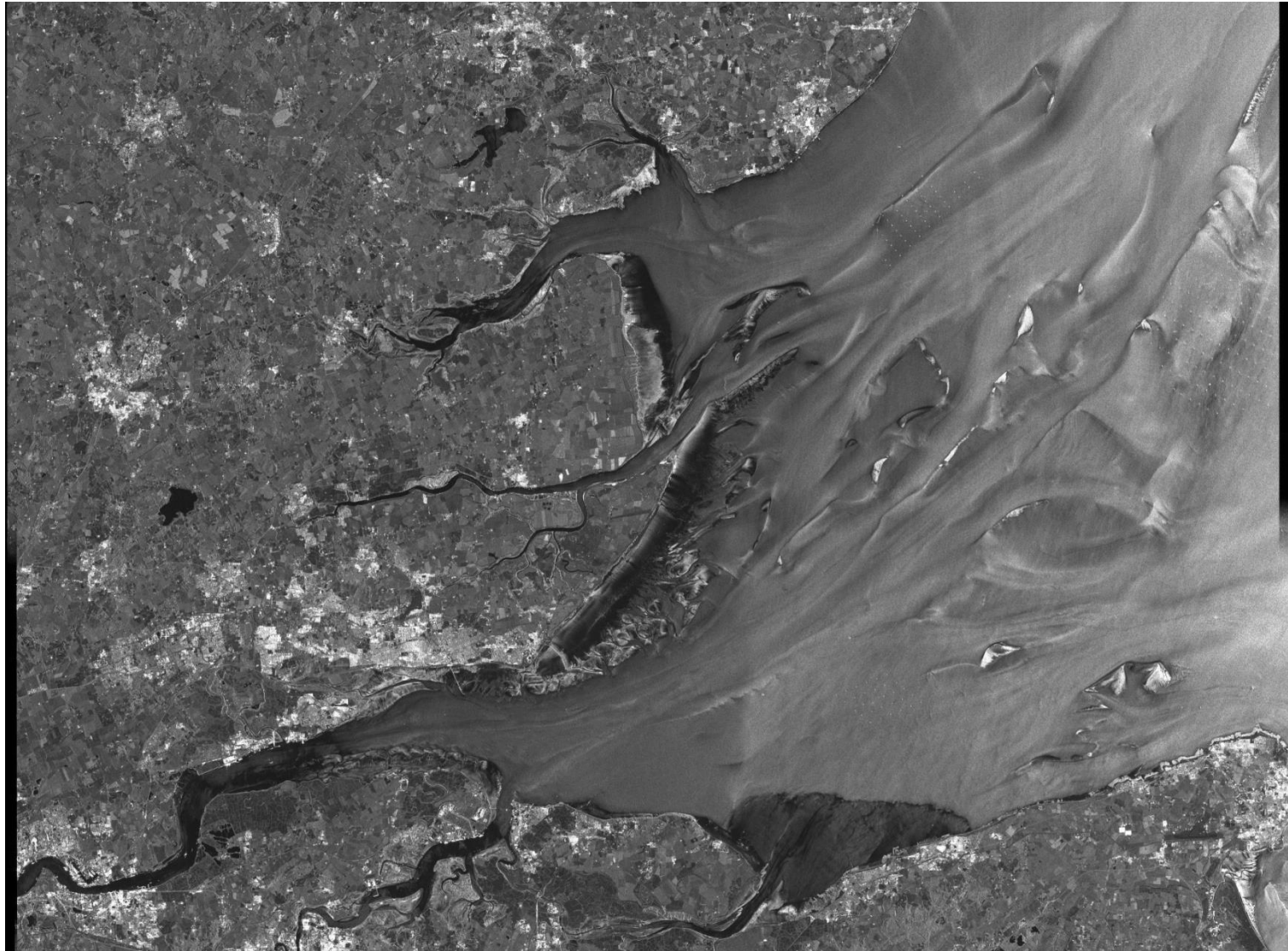
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■ Summary

- This presentation has shown that S1 products are of a high quality and have good radiometric and geometric calibration.
- The S1 performance requirements have been meet or exceeded.
- To achieve this, a number of point and distributed targets are used from around the world.
- Continual improvements are being made such as revised IW/EW elevation antenna patterns and recently improvements to WV2.
- Information is made available to users via N-Cyclic, Annual Performance Reports and Technical Reports.
- User support is provided by the MPC via questions sent to User Support and via the ESA STEP Forum.

■ And Finally ... Thank You



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