Assessment of third-party SAR missions in the framework of the Earthnet Data Assessment Pilot project

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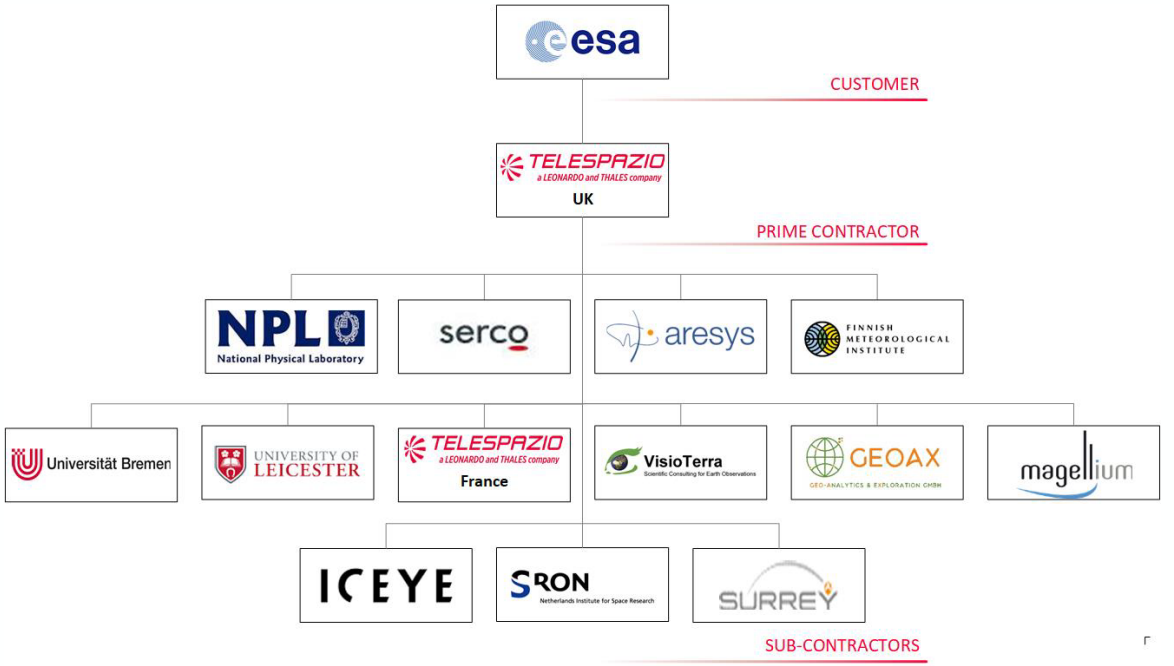
Outline

- Earthnet Data Assessment Pilot (EDAP) project
- Mission quality assessment matrix
- SAR missions quality assessment
  - IRF
  - Radiometry
- SAR missions assessment
  - SAOCOM
  - Capella
  - PAZ
  - Iceye
- Summary

Earthnet Data Assessment Pilot project

- The Earthnet Data Assessment Pilot (EDAP) is a project that is responsible for assessing the quality and suitability of candidate missions being considered for the Earthnet Third Party Missions (TPM)

- The key objective of ESA's EDAP is to take full advantage of the increased range of available data from non-ESA operated missions and to perform an early data assessment for various missions falling into one of these following instrument domains:
  - VHR, HR and MR Optical Missions
  - LR Optical Missions
  - SAR missions
  - Atmospheric Missions



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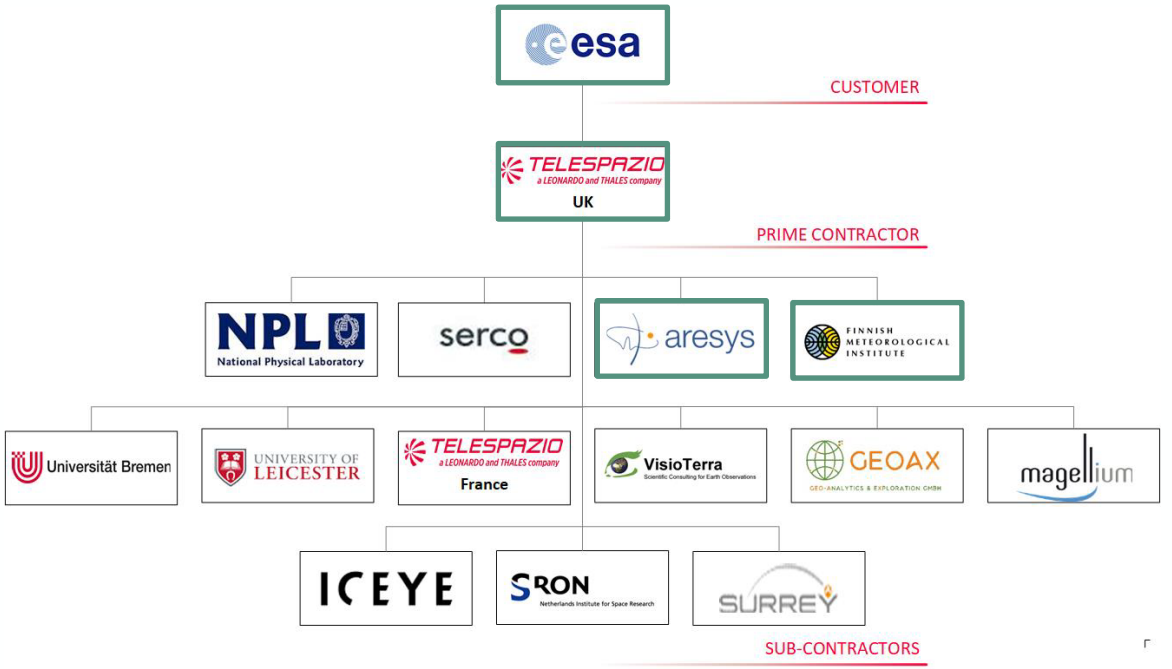
  - **SAR missions**
  - Atmospheric Missions



Mission Quality Assessment Matrix

- The mission quality assessment is based on specific guidelines and cover the following aspects:
  - ➢ Mission documentation review
  - ➢ Independent SAR data quality validation

- The results of the assessment are reported in dedicated mission reports that are published on the EDAP website

- The quality assessment follows a set of 'best practice' guidelines (available on EDAP website) aligned to the principles of QA4EO Framework

- The Mission Quality Assessment Matrix provides in a compact form the results of the performed validation activities.

Data Provider Documentation Review			Validation Summary
Product Information	**Metrology**	**Product Generation**	
Product Details	Sensor Calibration & Characterisation	Calibration Algorithm	Measurement Validation Method
Availability & Accessibility	Geometric Calibration & Characterisation	Geometric Processing	Measurement Validation Results Compliance
Product Format, Flags & Metadata	Metrological Traceability Documentation	Retrieval Algorithm	Geometric Validation Method
User Documentation	Uncertainty Characterisation	Mission-Specific Processing	Geometric Validation Results Compliance
	Ancillary Data		

<Entity> Detailed Validation			
Measurement		**Geometric**	
Measurement Validation Activity #1 Method	Measurement Validation Activity #1 Results Compliance	Geometric Validation Activity #1 Method	Geometric Validation Activity #1 Results Compliance
…	…	…	…

Key
Not Assessed
Not Assessable
Basic
Good
Excellent
Ideal
Not Public

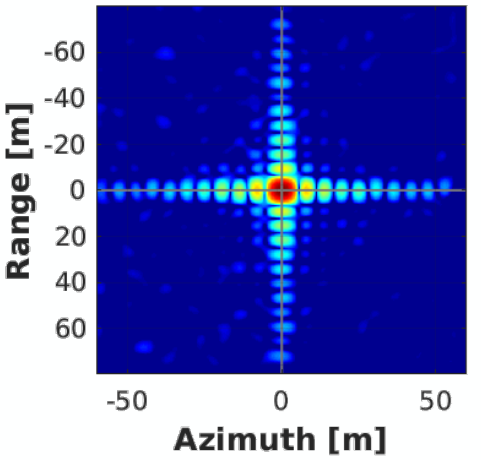
SAR Missions Quality Assessment

- The mission documentation review is aimed at evaluating the quality of the documentation available to the users in terms of products formats, and data generation and calibration;
- SAR products availability and accessibility to users is also assessed
- Independent SAR data quality assessment is performed on a set of the third-party SAR mission datasets over calibration sites
- Tools used for SAR data quality assessment:
  - ESA Snap Toolbox (if applicable)
  - Aresys SAR Quality Toolbox

Quality parameter	Metric	Data type	Cal. Sites
IRF	Spatial resolution	Point Target	Mission dedicated sites Rosamond Corner Reflector Array (California) Surat Basin (Australia)
	Peak-to-Side Lobe ratio	Point Target	
	Integrated Side Lobe ratio	Point Target	
Geometry	Localization	Point Target	
Radiometry	Calibration constant	Point Target	
	Elevation Antenna Pattern	Rain Forest	Amazon, Congo
	Azimuth scalloping	Rain Forest	
	Beam-to-beam offset	Rain Forest	
	Polarimetric imbalance	Rain Forest	
	ENL	Rain Forest	
	Noise level	Low backscatter	Doldrums

SAR IRF quality assessment

- SAR Impulse Response Function (IRF) analysis allows to assess the quality of the SAR data processing
- SAR IRF is assessed for bright point targets (e.g., transponders or large corner reflectors) that can be clearly identified in the SAR data
- Assessed quality parameters:
  - **Resolution**: main lobe with in azimuth and range directions is compared against product spec
  - **Side Lobe levels,** depending on applied windowing, are compared against product spec
  - **Absolute Calibration**: the target RCS in the SAR data is compare against the characterization value
  - **Geolocation**: the target SAR coordinates are compared against the known target position



IRF Analysis

Resolution

Range resolution : 5.7806 [m]

Azimuth resolution : 4.9428 [m]

PSLR

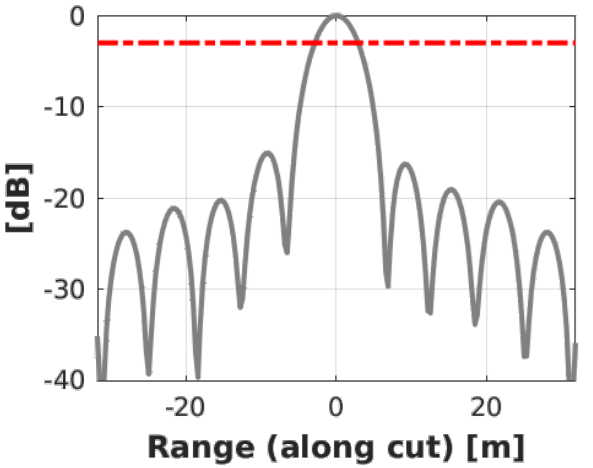
Range PSLR : -15.06 [dB]

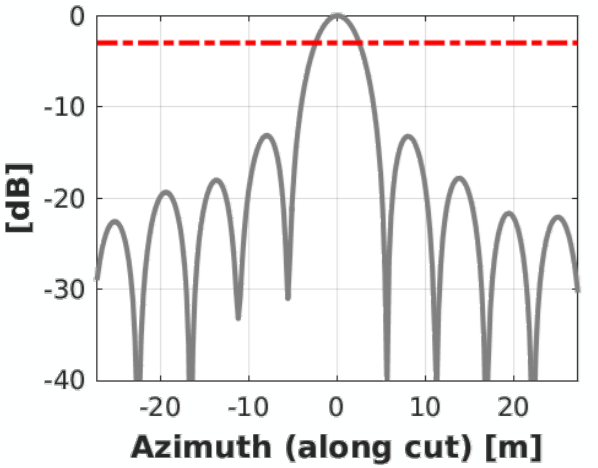
Azimuth PSLR : -13.1254 [dB]

ISLR

Range ISLR : -12.0756 [dB]

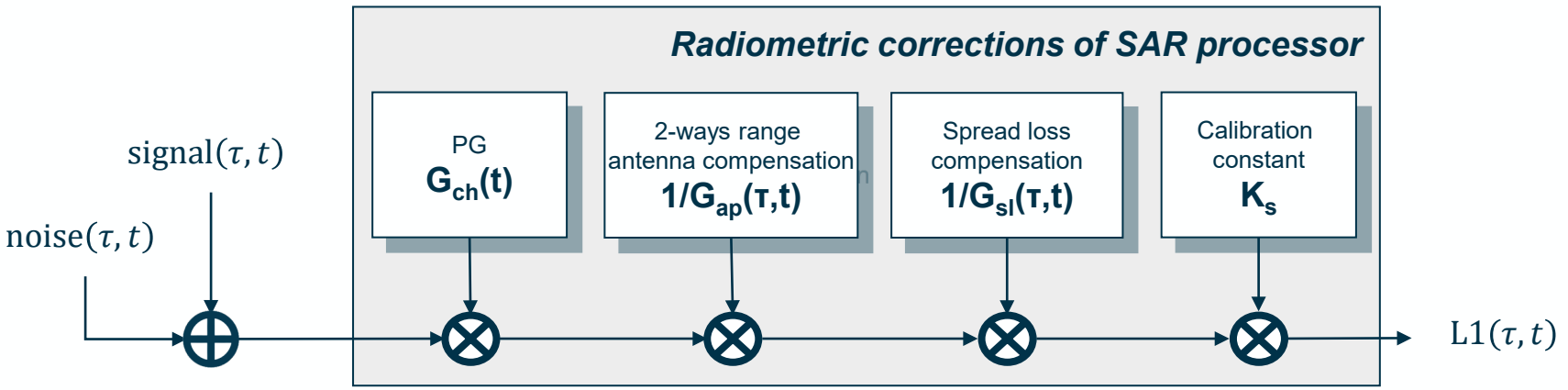
Azimuth ISLR : -10.0512 [dB]

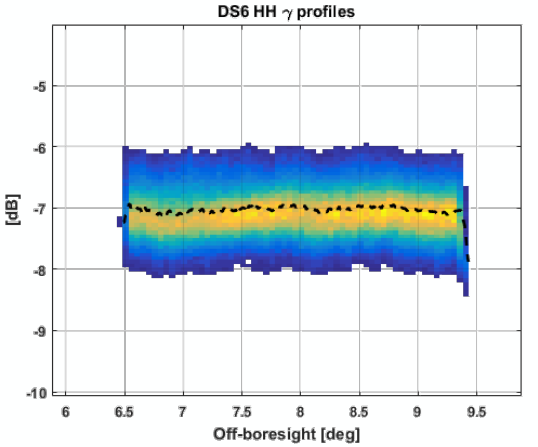


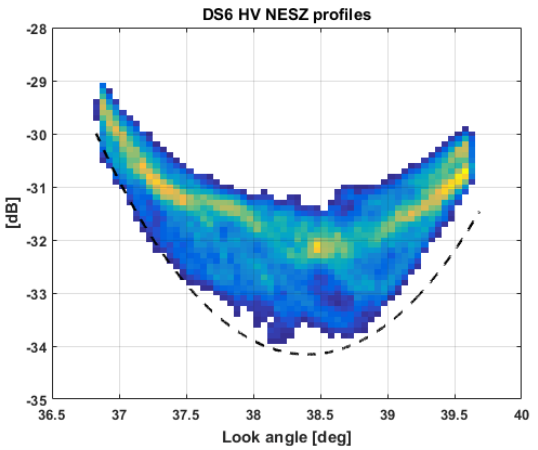


SAR radiometric quality assessment

- SAR processors introduce a set of radiometric corrections that shape both the signal and the noise levels
- The relative radiometric accuracy of the SAR data, depending on the accuracy of the applied corrections, can be verified for distributed targets with a homogeneous backscatter
- The γ^0 profiles are measured over Rain Forests data
- The noise profiles are measured over low backscatter areas and compared against theoretical or annotated values







EDAP SAR missions assessment

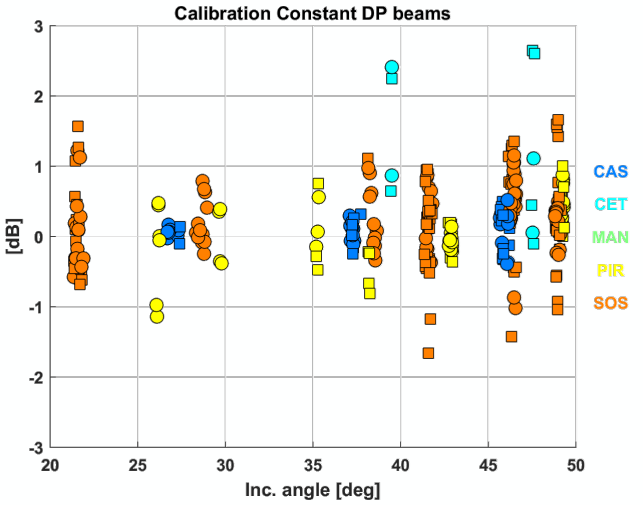
- In the framework of the EDAP project (2019-2021) 4 SAR missions have been evaluated and corresponding reports have been published on the EDAP website

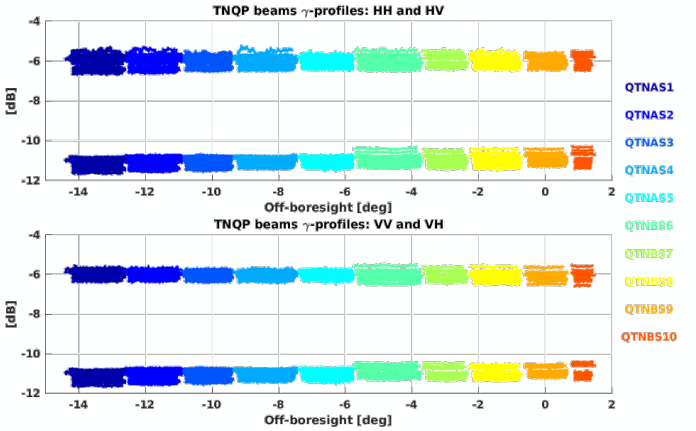
Mission	Owner	Band	Pol	Acquisition Modes	Resolution (az x rg)	Assessed Satellites	Launch date	Notes
SAOCOM	CONAE (Argentina)	L	Full	Stripmap TopSAR	5/6 x 10 m 30/100 x 10 m	SAOCOM-1A SAOCOM-1B	2018 2020	Repeat cycle 16 days (8 days for constellation)
PAZ	Hisdesat (Spain)	X	Dual	Stripmap ScanSAR Spotlight	<= 3 m <= 40 m 0.25 m (best)	PAZ	2018	Comparison with Cosmo SkyMed and TerraSAR-X data performed
CAPELLA	Capella Space (USA)	X	Single	Stripmap Sliding Spotlight Staring Spotlight	1.2 x 0.75 m 1.0 x 0.5 m 1.0 x 0.3 m	Capella 3 Capella 5	2021	Assessed satellites operate in a polar SSO with 97° inclination
ICEYE	Iceye (Finland)	X	Single	Stripmap ScanSAR Spotlight	<= 3 m 15 x 15 m <= 0.5 m	X2, X4, X6, X7	2018-2020 (X2-X7 satellites)	Strip and Spot acquisition modes assessed

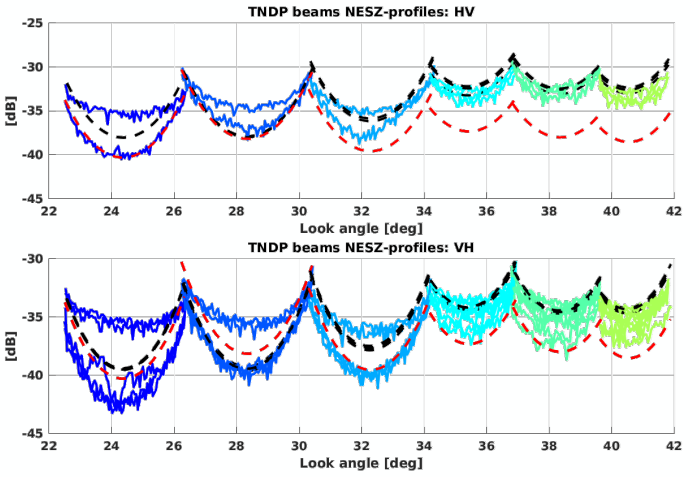
SAOCOM mission assessment

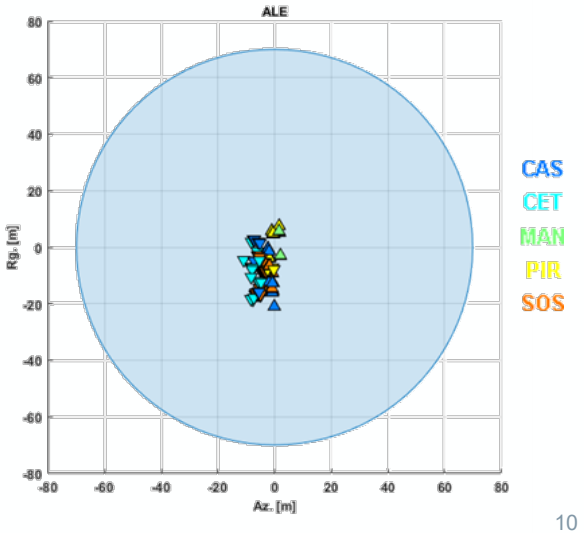
- Product documentation in good status
- SAOCOM catalogue allowing to easily identify needed products and download/reprocess the data (depending on user permissions)
- Data quality assessment shows pretty good calibration status (geolocation accuracy can be improved)

Product Information	Product Generation	Ancillary Information	Uncertainty Characterisation	Validation
Product Details	Sensor Calibration & Characterisation Pre-Flight 🔒	Product Flags	Uncertainty Characterisation Method 🔒	Reference Data Representativeness
Availability & Accessibility	Sensor Calibration & Characterisation Post-Launch 🔒	Ancillary Data	Uncertainty Sources Included 🔒	Reference Data Quality
Product Format	Additional Processing		Uncertainty Values Provided 🔒	Validation Method
User Documentation			Geolocation Uncertainty 🔒	Validation Results
Metrological Traceability Documentation 🔒				





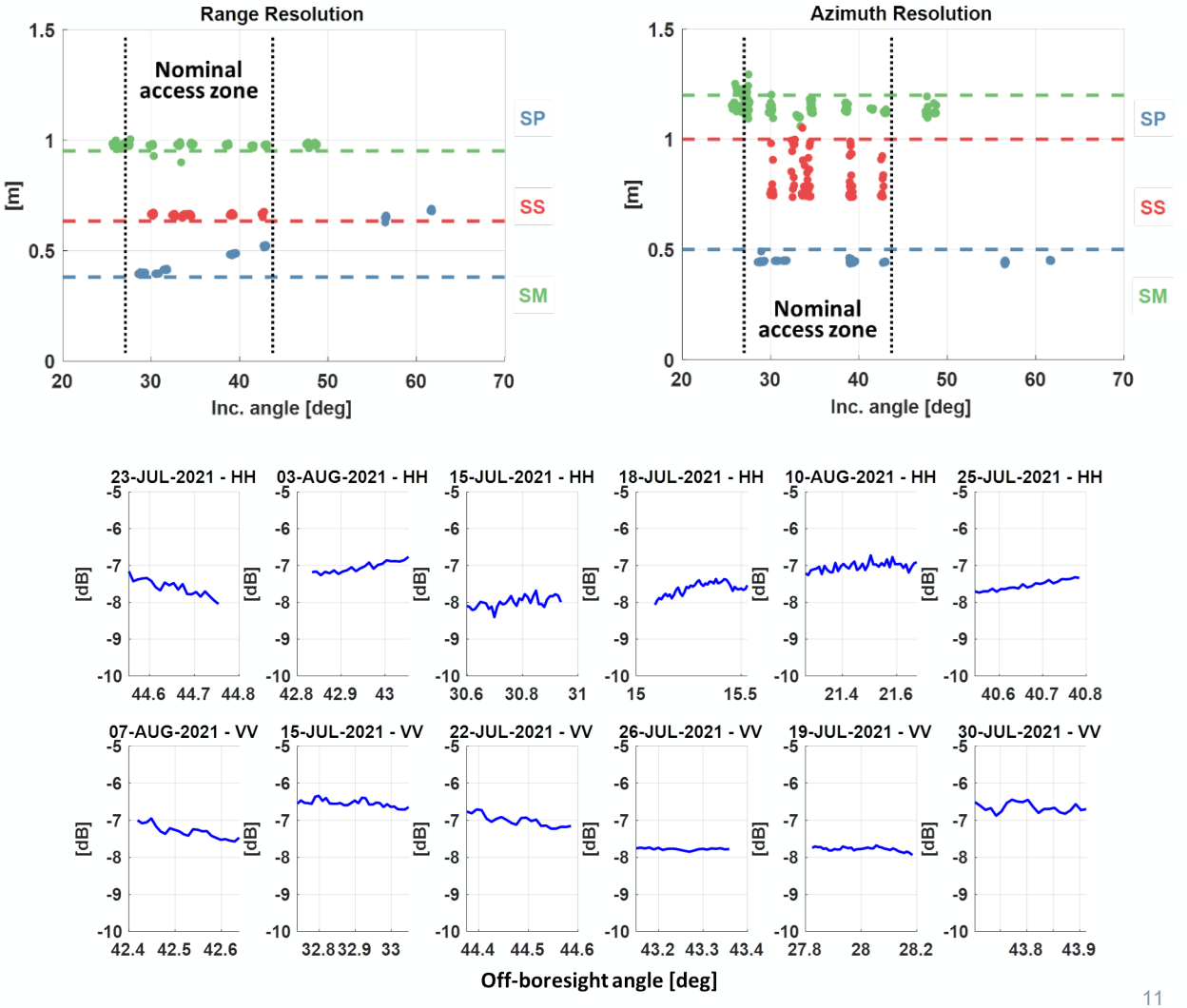




CAPELLA mission assessment

- Product documentation in good status
- CAPELLA catalogue allowing to easily identify and order needed data and to perform tasking of needed acquisitions
- Data quality assessment shows good calibration status (radiometric calibration can be improved)

Product Information	Product Generation	Ancillary Information	Uncertainty Characterisation	Validation
Product Details	Sensor Calibration & Characterisation Pre-Flight	Product Flags	Uncertainty Characterisation Method	Reference Data Representativeness
Availability & Accessibility	Sensor Calibration & Characterisation Post-Launch	Ancillary Data	Uncertainty Sources Included	Reference Data Quality
Product Format	Additional Processing		Uncertainty Values Provided	Validation Method
User Documentation			Geolocation Uncertainty	Validation Results
Metrological Traceability Documentation				



PAZ & ICEYE mission assessments

PAZ

- Basic publicly available product documentation available. No documentation describing Cal-Val activities performed by data provider.
- Data assessment shows good quality in all analyzed aspects. Quality in line with product specifications.

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Product Details	Sensor Calibration & Characterisation Pre-Flight	Product Flags	Uncertainty Characterisation Method	Reference Data Representativeness
Availability & Accessibility	Sensor Calibration & Characterisation Post-Launch	Ancillary Data	Uncertainty Sources Included	Reference Data Quality
Product Format	Additional Processing		Uncertainty Values Provided	Validation Method
User Documentation			Geolocation Uncertainty	Validation Results
Metrological Traceability Documentation				

ICEYE

- In addition to the publicly available product documentation, comprehensive documentation about Cal-Val activities performed by ICEYE was provided (upon request).
- Data assessment showed good quality for most analyzed aspects. Quality sometimes lower than the claimed values.

Product Information	Product Generation	Ancillary Information	Uncertainty Characterisation	Validation
Product Details	Sensor Calibration & Characterisation Pre-Flight	Product Flags	Uncertainty Characterisation Method	Reference Data Representativeness
Availability & Accessibility	Sensor Calibration & Characterisation Post-Launch	Ancillary Data	Uncertainty Sources Included	Reference Data Quality
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User Documentation			Geolocation Uncertainty	Validation Results
Metrological Traceability Documentation				

PAZ & ICEYE mission assessments

Legend:
Measured quality with respect to claimed values

Better
Slightly better
Similar or slighly worse
Worse

Geolocation accuracy (m)

Im. mode	X2		X4		X6		X7		PAZ	
	Rg.	Az.	Rg.	Az.	Rg.	Az.	Rg.	Az.	Rg.	Az.
SC									4.1	3.3
SM	3-13	5-9	0-11	2-9	3-7	1-4	3-7	3-6	2.7	0.2
SL			0-14	1-6					2.7	0.25
SLH (Spot)			2-16	1-5	2-3	0-2	0-4	5-9	2-3	0.2

NESZ (dB)

Im. mode	X2	X4	X6	X7	PAZ (single-pol)	PAZ (dual-pol)
SC					-20	
SM	-15…-13	-26…-13	-14…-11	-20…-15	-23…-22	-23.4
SL		-13…-11			-18.4	-15.9
SLH (Spot)			-13…-10	-14…-12		-19.7

Radiometric stability (dB), ICEYE X4-X7

Im. mode	X4	X6	X7
SM	-1.36 ± 0.61	-4.49 ± 0.46	-3.66 ± 0.66
	-7.51 ± 0.72	-5.15 ± 0.44	-6.41 ± 0.91
	-8.43 ± 0.54	-7.29 ± 0.77	-4.56 ± 0.63
	-5.13 ± 0.32		-5.26 ± 0.89
SL	-6.22 ± 0.19		
	-4.25 ± 0.21		
	-4.77 ± 0.22		
	-5.01 ± 0.17		
SLH		-6.00 ± 0.57	-4.29 ± 0.62
		-5.21 ± 0.56	-4.60 ± 0.62
		-5.09 ± 0.55	-4.58 ± 0.55
		-6.23 ± 0.63	-4.55 ± 0.60

Peak side lobe ratio (dB)

Im. mode	X2		X4		X6		X7		PAZ	
	Rg.	Az.	Rg.	Az.	Rg.	Az.	Rg.	Az.	Rg.	Az.
SC									-24…-23	-27…-26
SM	-15…-9	-15…-10	-13…-9	-15…-13	-12	-15…-14	-13	-15	-27…-26	-31…-29
SL			-14…-12	-14…-12					-26…-25	-30…-29
SLH (Spot)			-17…-12	-15…-12	-13	-13…-11	-14…-13	-13…-12	-26…-23	-32…-29

Spatial resolution (m)

Im. mode	X2		X4		X6		X7		PAZ	
	Rg.	Az.	Rg.	Az.	Rg.	Az.	Rg.	Az.	Rg.	Az.
SC									16.6	19.2
SM	0.6-1.5	2.5	0.9-1.8	2.2-2.3	0.91	2.2	1.0	2.3	1.75	2.95
SL			0.45	0.6-0.8					1.2	1.55
SLH (Spot)			0.47	0.24	0.46	0.23	0.45	0.22	0.6	1.1

PAZ-TSX-CSK data quality comparison

- Publicly available product documentation of PAZ, TerraSAR-X and Cosmo-SkyMed were used as a reference.
- Data quality of the three sensors was intercompared.
- The quality of the all analyzed PAZ, TSX and CSK data was generally in line with the values provided in the product documentation.
- As expected, the quality of PAZ and TSX was very similar. CSK showed more differences in quality due to different instrument configurations than in PAZ and TSX.

Relative performance between PAZ, TSX and CSK

Sensor	Aq. mode	Spatial resolution	Geolocation accuracy	NESZ	Side lobes	Antenna elevation pattern	Equivalent number of looks
PAZ	SC						
	SM						
	SL&HS						
TSX	SC						
	SM						
	SL&HS						
CSK	SC						
	SM						

Legend

Better
Average
Weaker

Summary

- In the framework of the EDAP project, candidate missions being considered for the Earthnet Third Party Missions (TPM) are assessed by experts
- The following SAR missions have been assessed during the first EDAP project (2019-2021):
  - Saocom
  - Paz
  - Capella
  - ICEYE
- During the second EDAP project (2022-2024), the following SAR missions will be assessed:
  - ICEYE (new satellites and InSAR and ScanSAR products)
  - Spacety SAR Constellation (C-band)
  - Umbra-SAR (X-band)
  - NovaSAR-1 (S-band)