

# Quality Assessment of ICEYE and SAOCOM InSAR Data Within ESA's EDAP+ Activity



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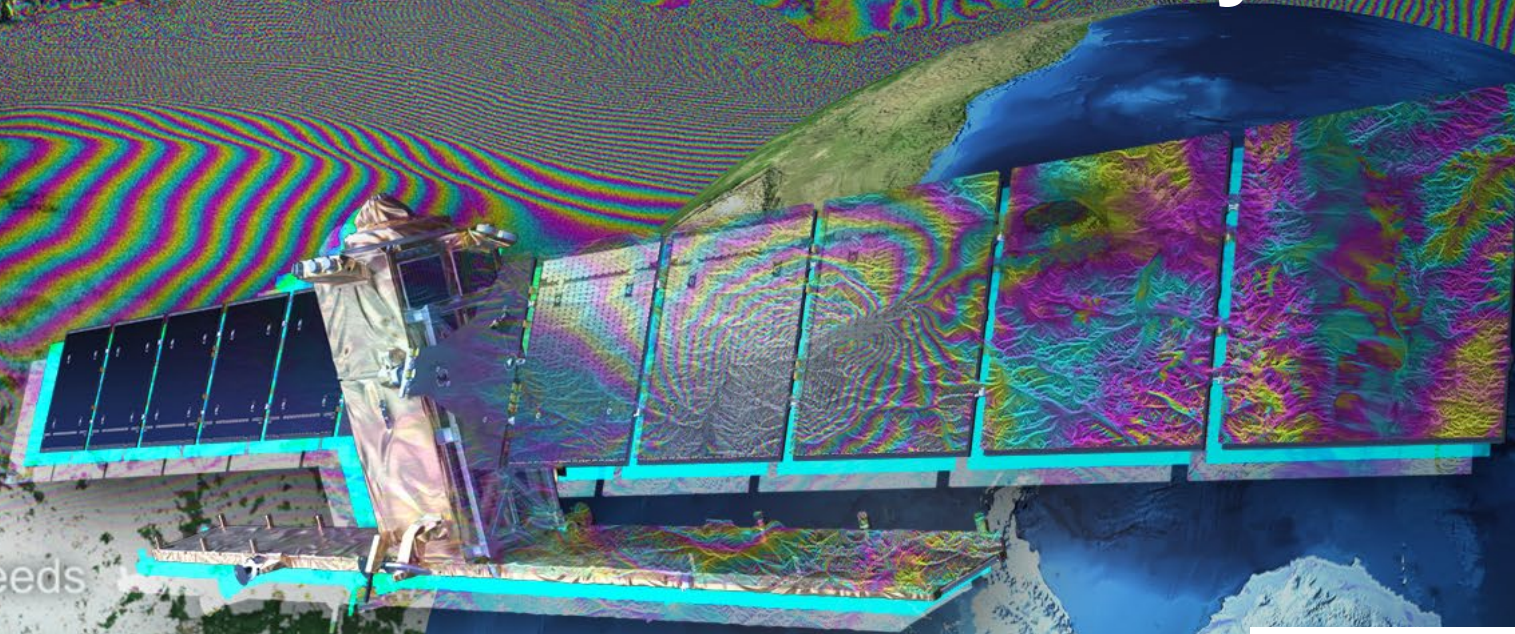
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FRINGE 2023

University of Leeds, UK | 11 - 15 September 2023.

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# Earthnet Data Assessment Pilot project

- The Earthnet Data Assessment Project (EDAP) 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
  - AIS & RF Missions



CUSTOMER



PRIME CONTRACTOR



SUB-CONTRACTORS

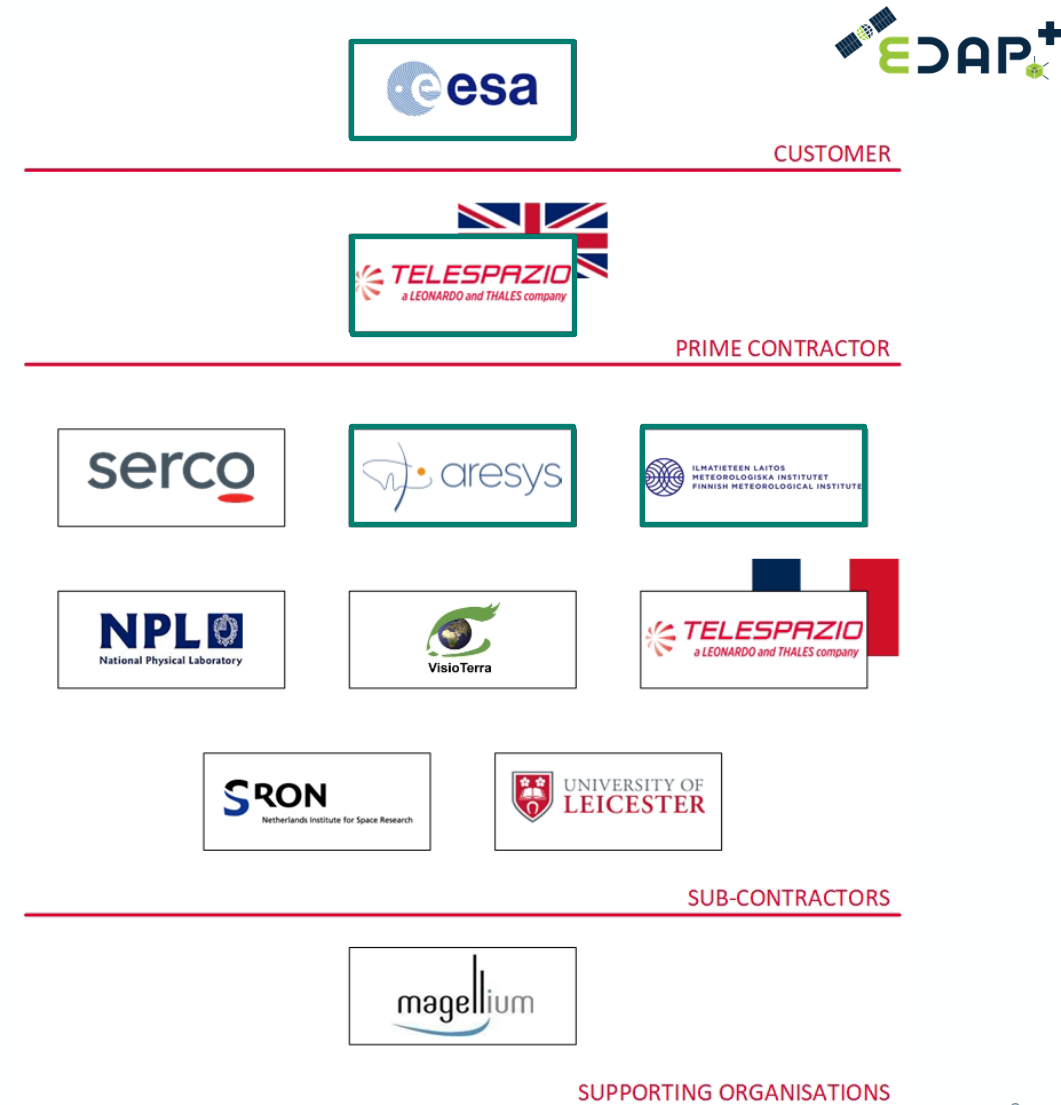


SUPPORTING ORGANISATIONS



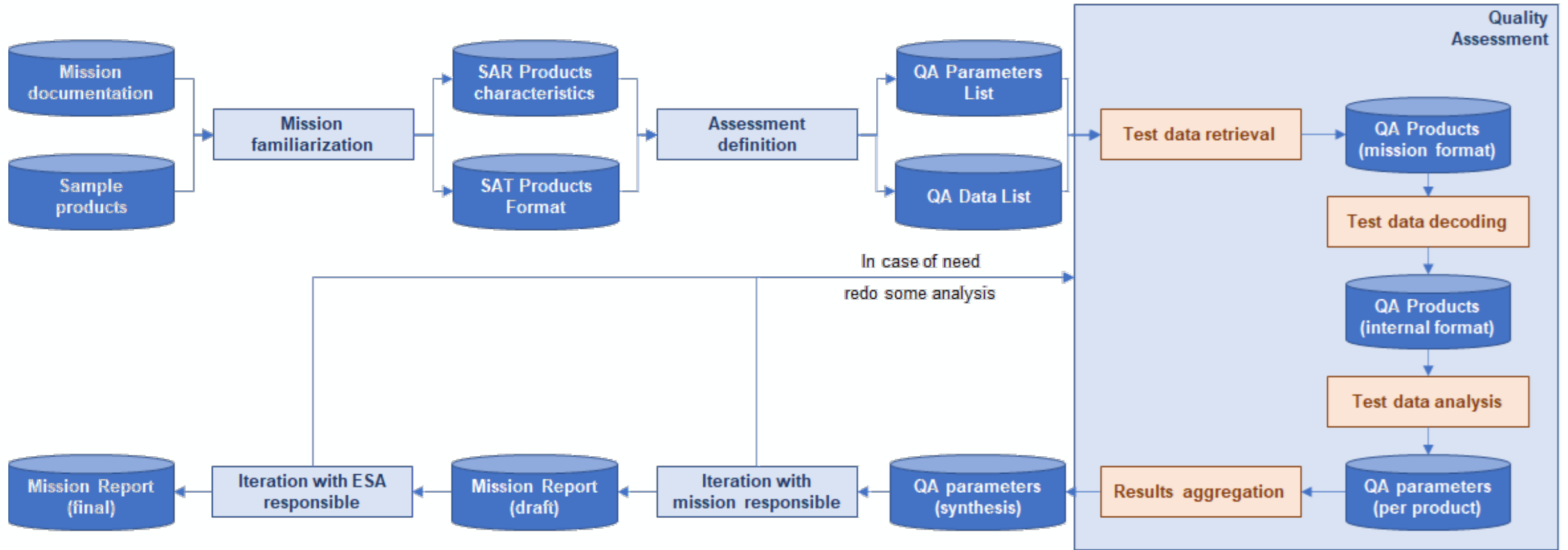
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  - LR Optical Missions
  - **SAR missions**
  - Atmospheric Missions
  - AIS & RF Missions



# Quality Assessment Process Flow Chart

QAP approach defined and optimized during the first EDAP project



# 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	Radiometric Calibration & Characterisation	Radiometric Calibration Algorithm	Radiometric Validation Method
Availability & Accessibility	Geometric Calibration & Characterisation	Geometric Processing	Radiometric 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			

Key
Not Assessed
Not Assessable
Basic
Good
Excellent
Ideal
🔒 Not Public

<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 🔒
...	...	...	...



# SAR Missions Quality Assessment

- The mission documentation review is aimed at evaluating the quality of the documentation available to the users
- 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
  - Aresys SAR Quality Toolbox
  - ISCE2 (for InSAR data)
  - ESA's SAR Calibration Toolbox

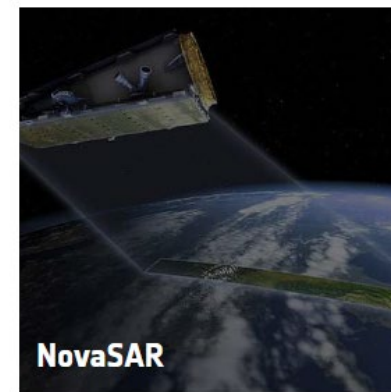
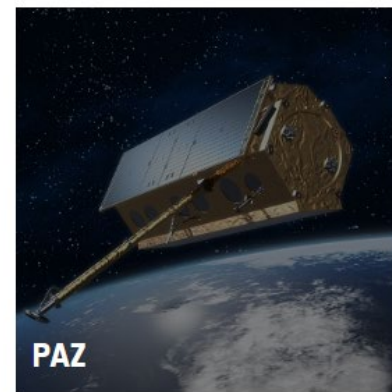
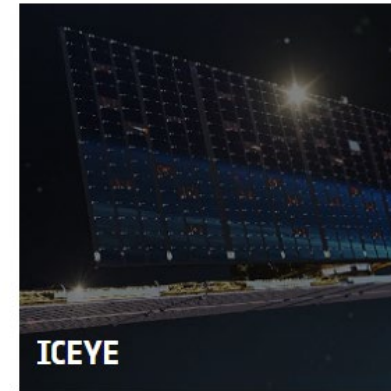
Quality parameter	Metric	Data type	Cal. Sites
IRF	Spatial resolution	Point Target	Mission dedicated sites Rosamond Corner Reflector Array (California) Surat Basin (Australia) Neustrelitz (Germany)
	Peak-to-Side Lobe ratio	Point Target	
	Integrated Side Lobe ratio	Point Target	
Geometry	Localization	Point 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 Missions Quality Assessment

- EDAP
- EDAP+

- Technical Notes on Quality Assessment for SAR missions:

- SAOCOM (L-band)
  - SAOCOM 1-A and 1-B
  - InSAR
- ICEYE (X-band)
  - X2
  - X4, X6 & X7
  - X8-13
  - InSAR
  - ScanSAR
- Capella (X-band)
- PAZ (X-band)
  - Quality Assessment
  - PAZ-TSX-CSK intercomparison
- NovaSAR (S-band)
- RISAT-1 (C-band)
- RISAT-1 and Sentinel-1 intercomparison



- All technical notes available at:  
<https://earth.esa.int/eogateway/activities/edap/sar-missions>

- EDAP+ project has officially started in July 2022 with a foreseen duration of two years
- The project foresees the assessment of other potential missions to be defined
- Assessment of InSAR quality will be performed for the first time in the framework of the EDAP+ project



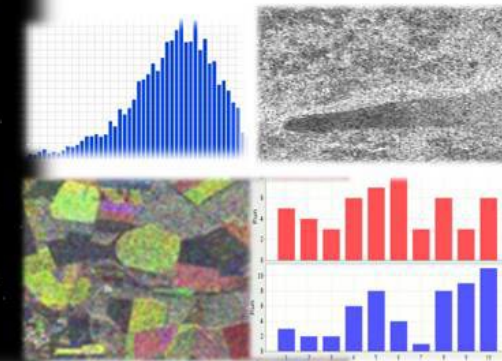
- Currently the largest available SAR constellation
- One of ESA's Earthnet Third Party Missions (TPM)
- Providing SAR data as a Contributing Mission to all of Copernicus services since end of 2021
- Imaging modes: Spot, Strip and Scan
- Already assessed during the first EDAP project
- New assessment includes
  - Satellites X8-13
  - X6 for InSAR: Spot and Strip modes
  - Scan
  - SAR video products (optionally) - dwell



Image mode	Slant res. (m)	Ground res. (m)	Scene size (km)	Inc. ang.
Spot	0.5 x 0.25	1.0 x 1.0	5 x 5	20-35°
Strip	0.5-2.5 x 3.0	3.0 x 3.0	30 x 50	15-30°
Scan		15 x 15	100 x 100	21-29°

# SAOCOM mission

- Operated by Argentina's space agency CONAE
- Constellation of 2 twin satellites (16 / 8 days temporal baseline)
- 625 – 650 km altitude
- L-band SAR instrument, 50 MHz band
- Full-pol, active array antenna (7 x 20 phase centers)
- Assessment of InSAR products will start when new product version is available



1. Interferometric baseline computed from the orbits annotated in the products
2. Doppler Centroid annotated in the products
3. Interferometric coherence from interferograms generated applying co-registration from orbit only
4. Interferometric coherence from interferograms generated applying co-registration refinement from data (ESD or incoherent speckle tracking)
5. For quad pol – comparison of the HH-VV coherence (not relevant in ICEYE)

\* Analyses 3 and 4 are useful for assessing the accuracy of orbit information

# ICEYE InSAR assessment - Data ordering

- Test area:
  - Atacama Desert, South America
  - Dry mountainous area with salt lakes
  - High interferometric coherence
- Data:
  - ICEYE X6 satellite
  - Strip and Spot complex data products (SLC)
  - 5 stacks of 4 acquisitions for each imaging mode
  - 1-2 days temporal baseline between the acquisitions
  - Total of 20 Strip and 20 Spot products
  - Data acquired during Aug-Sep 2023



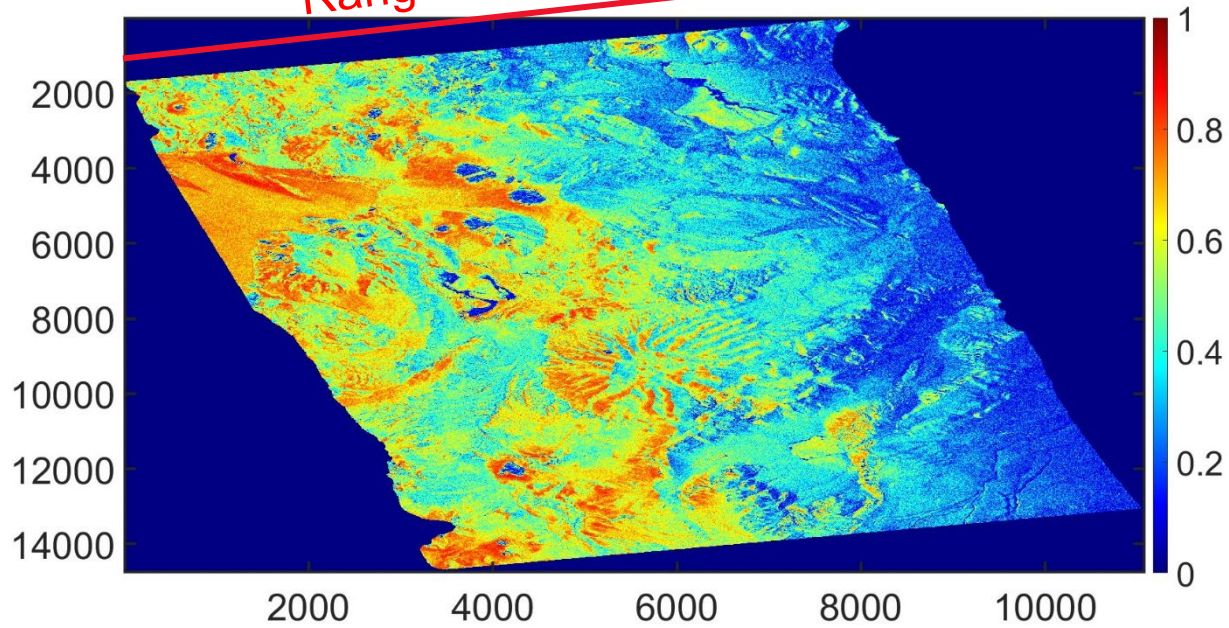
# ICEYE InSAR assessment - Results

Mode	Pairs
SL	20230808-20230809
	20230811-20230812
SLH	20230710-20230711
	20230713-20230714
	20230722-20230723
	20230725-20230726
SM	20230716-20230717
	20230719-20230720
	20230802-20230803
	20230805-20230806
	20230814-20230815
	20230817-20230818
	20230826-20230827
	20230829-20230830

- All the processing performed using ESA's SNAP.
- Coregistration was found to be a challenging task.
  - Possible orbit imprecision and/or geolocation inaccuracies.
  - Even more challenging with the high spatial resolution offered in some ICEYE's modes (SLH → 0.5x0.25), and relatively coarse DEMs.
- In the pairs working, moderate-high coherence was found.
- Presence of artifacts for StripMap mode.

# ICEYE InSAR assessment - Results

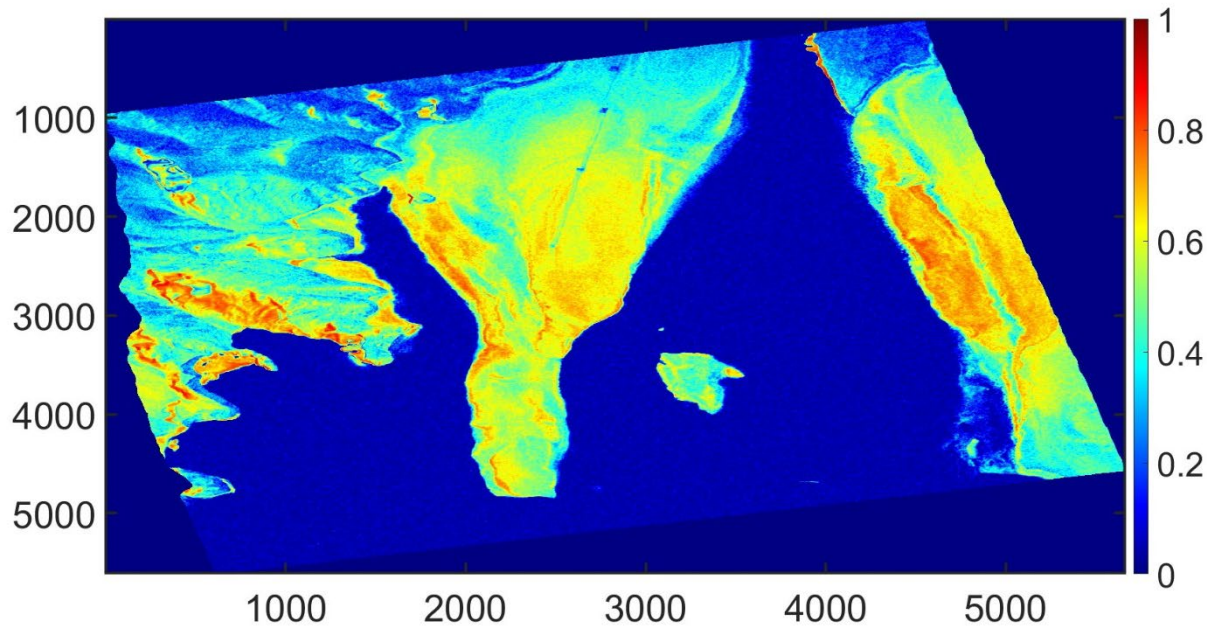
Range Direction



Strip  
14<sup>th</sup> August 2023  
15<sup>th</sup> August 2023



# ICEYE InSAR assessment - Results



Spot  
11<sup>th</sup> August 2023  
12<sup>th</sup> August 2023



- ESA EDAP project, general overview
  - Candidate missions 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):
    - ICEYE, SAOCOM, PAZ, Capella, TerraSAR-X, Cosmo-SkyMed (no InSAR assessment)
  - During the second EDAP+ project (2022-2024), the following SAR missions are assessed:
    - ICEYE (new satellites + InSAR + ScanSAR), SAOCOM (InSAR), Riset-1A, NovaSAR-1
- ICEYE InSAR data assessment
  - The interferometric quality of 20 Strip and 20 Spot data products is being assessed
  - Data acquired from the Atacama Desert, South America
    - Dry mountainous terrain with salt lakes – optimal for InSAR
  - Analysis results are still scarce.
    - Need for better/finer processing of the images.
    - Possible improvement in the orbit accuracy from ICEYE.