



Ministry of Science and Higher Education
Republic of Poland



JAGIELLONIAN UNIVERSITY
IN KRAKÓW



EUROPEAN SPACE AGENCY

15 - 19 June 2026 | Auditorium Maximum of the Jagiellonian University, Kraków, Poland

FRINGE 2026

Sentinel-1 Product Performance

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<https://sar-mpc.eu/about/activities-and-team/>

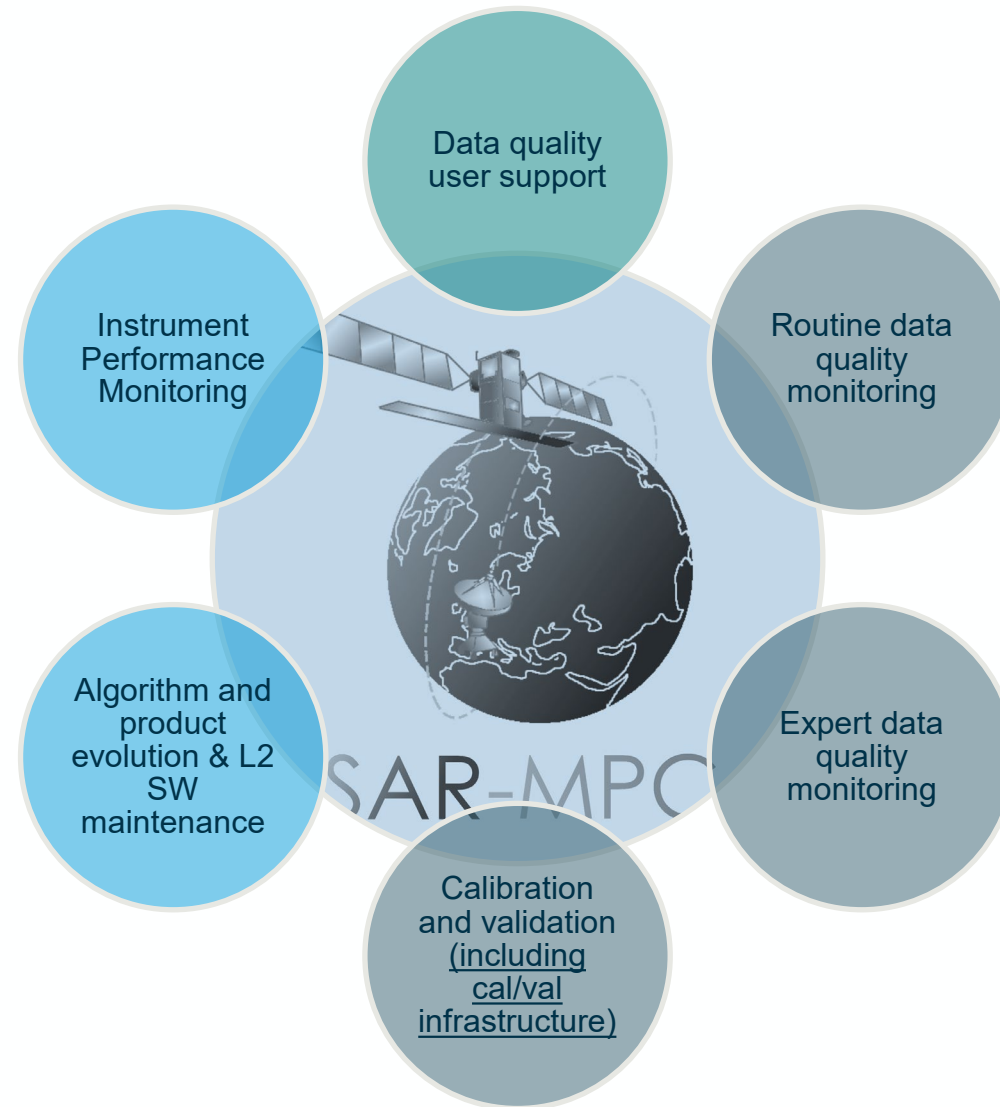
ESA UNCLASSIFIED - For ESA Official Use Only



→ THE EUROPEAN SPACE AGENCY

-
- Leeds
- 11 - 15 SEPTEMBER 2023 UNIVERSITY OF LEEDS
- # FRINGE 2023
- AGENDA WITH PRESENTATIONS
- FRINGE2023 SUMMARIES AND RECOMMENDATIONS
- REWATCH

Sentinel-1 Continuous cal/val



For user support or feedback, please submit a request or contact

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The bottom right corner features the SAR-MPC logo, which includes a small globe icon with a satellite orbiting it, followed by the text "SAR-MPC" in a stylized font. To the right of this is the ESA (European Space Agency) logo, consisting of a stylized "e" inside a circle followed by the letters "esa".



- **S1-A:** Relative Orbit Number = mod (Absolute Orbit Number orbit - 73, 175) + 1
- **S1-B:** Relative Orbit Number = mod (Absolute Orbit Number orbit - 27, 175) + 1
- **S1-C:**
 - Relative Orbit Number = mod (Absolute Orbit Number orbit - 172, 175) + 1 **until 2026-06-24**
 - Relative Orbit Number = mod (Absolute Orbit Number orbit - 99, 175) + 1 **from 2026-06-24**
- **S1-D:** Relative Orbit Number = mod (Absolute Orbit Number orbit - 42, 175) + 1

Instrument Performance: Doppler monitoring



SAR-MPC

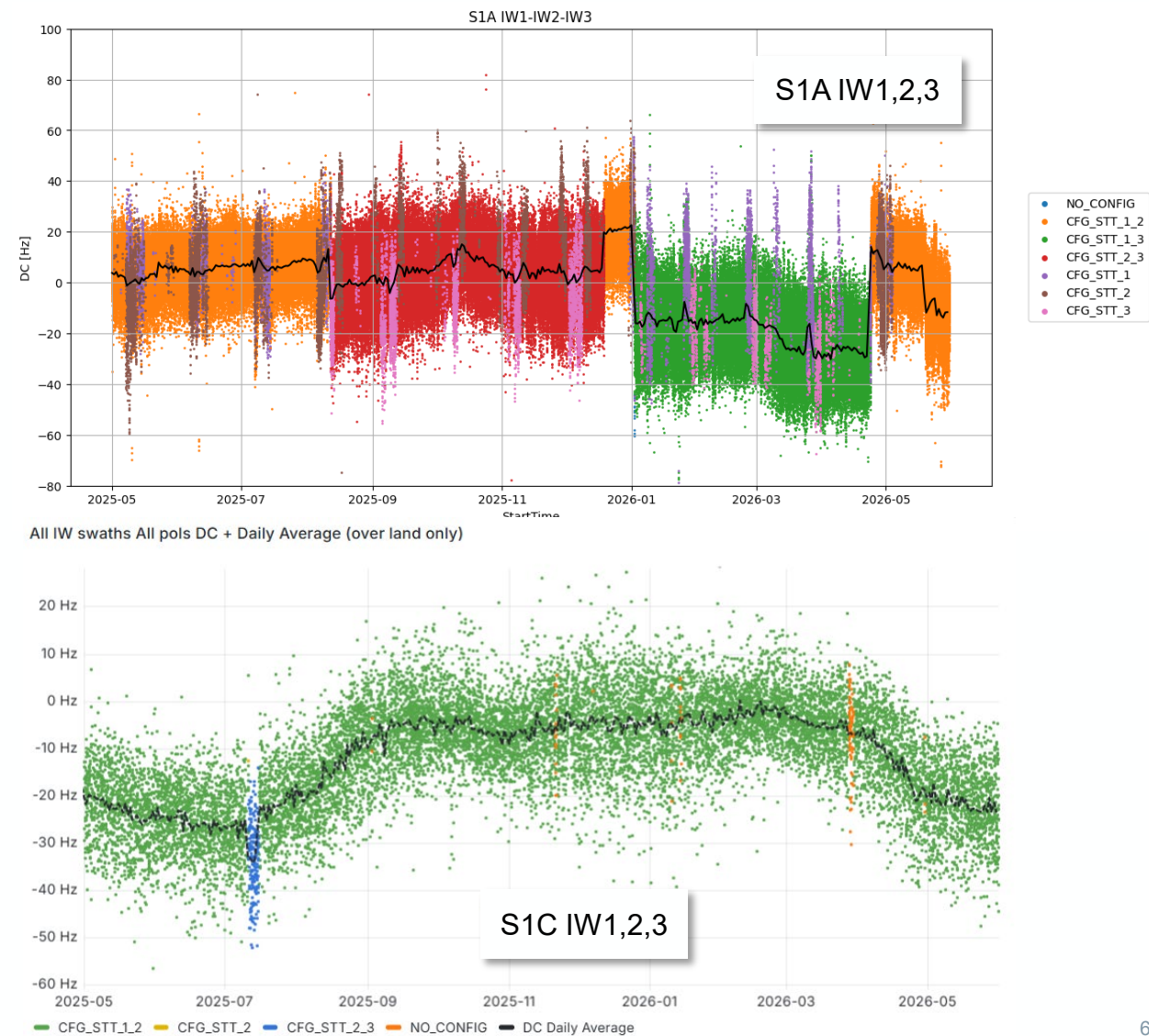


Instrument health is checked via different monitoring:

- Error matrices (Antenna Status)
- Instrument Noise
- Instrument Temperature
- PG gain and phase
- Doppler
- Baselines and Burst Sync

S-1A Doppler pointing has shown jumps of ~30Hz since mission start and increased to ~50Hz in 2024. Following the STT re-alignment in summer 2024, the jumps were reduced and remained stable. However, since the beginning of 2026, frequency jumps of around 50 Hz have been observed again.

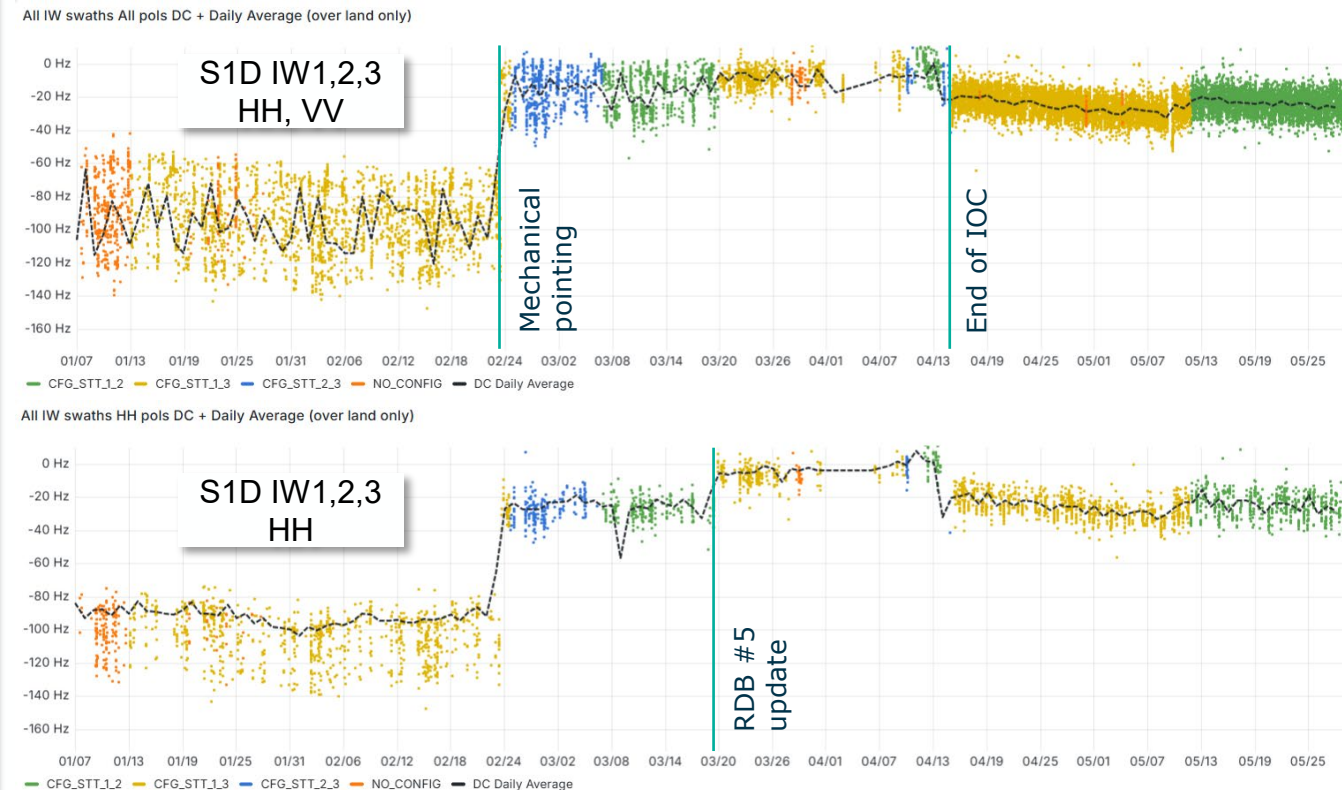
S-1C Doppler stable with seldom STT changes and small jumps between configurations



Instrument health is checked via different monitoring:

- Error matrices (Antenna Status)
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S-1D Doppler stable with seldom STT changes and small jumps between configurations. On 23rd Feb it was implemented an on-board correction of the sensor mis-pointing, leading to a DC jump of around 100 Hz. On 19th March, the RDB #5 file was updated to eliminate 20 Hz difference between HH and VV polarizations.



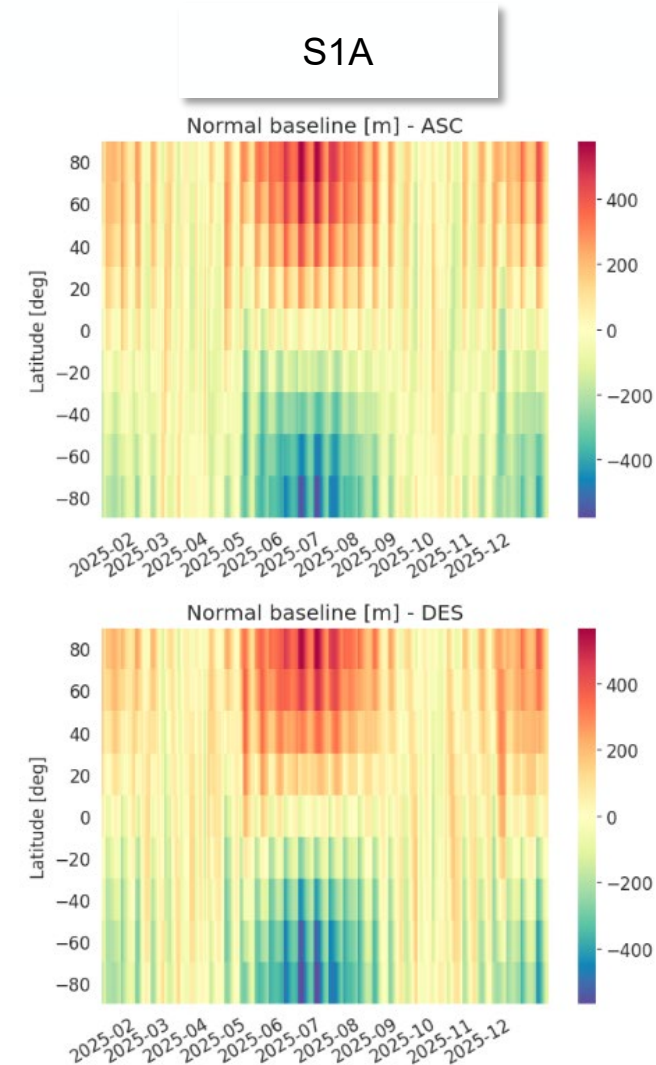


Instrument health is checked via different monitoring:

- Error matrices (Antenna Status)
- Instrument Noise
- Instrument Temperature
- PG gain and phase
- Doppler
- Baselines and Burst Sync

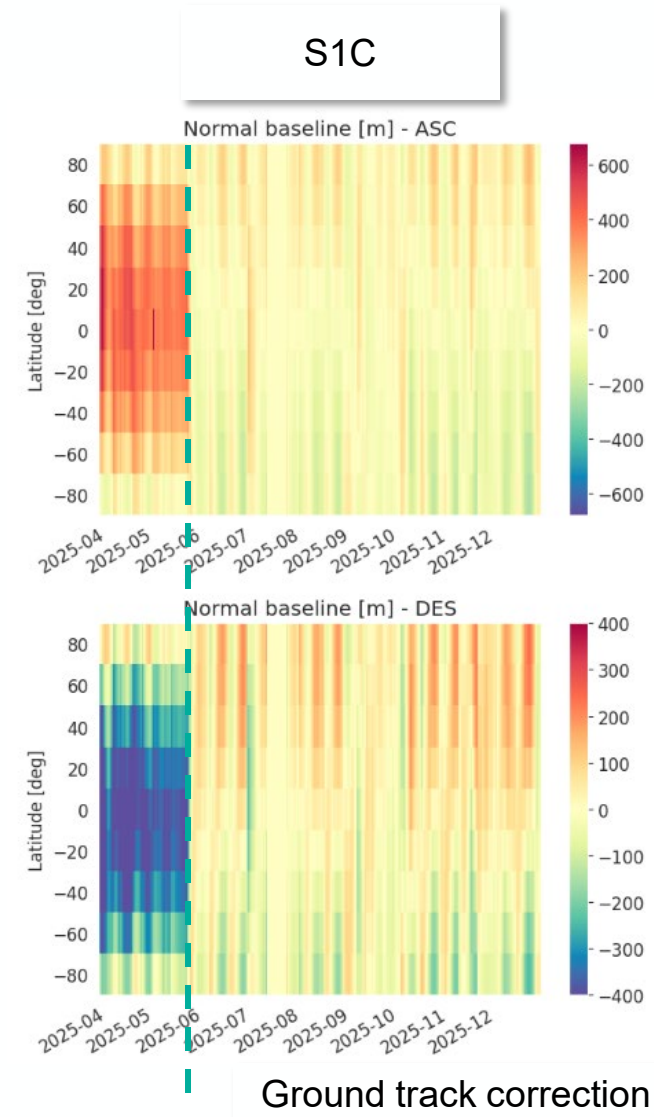
Effect of lack of out of plane maneuver for S1A

- Average normal baseline evolution since January 2024 shows an increase, in particular in summer and for high latitudes due to lack of out of plane maneuvers
- Same increased observed in along-track baselines, resulting in small decrease of burst synchronization along the data-take
- Effect still limited to a fraction of the critical baseline

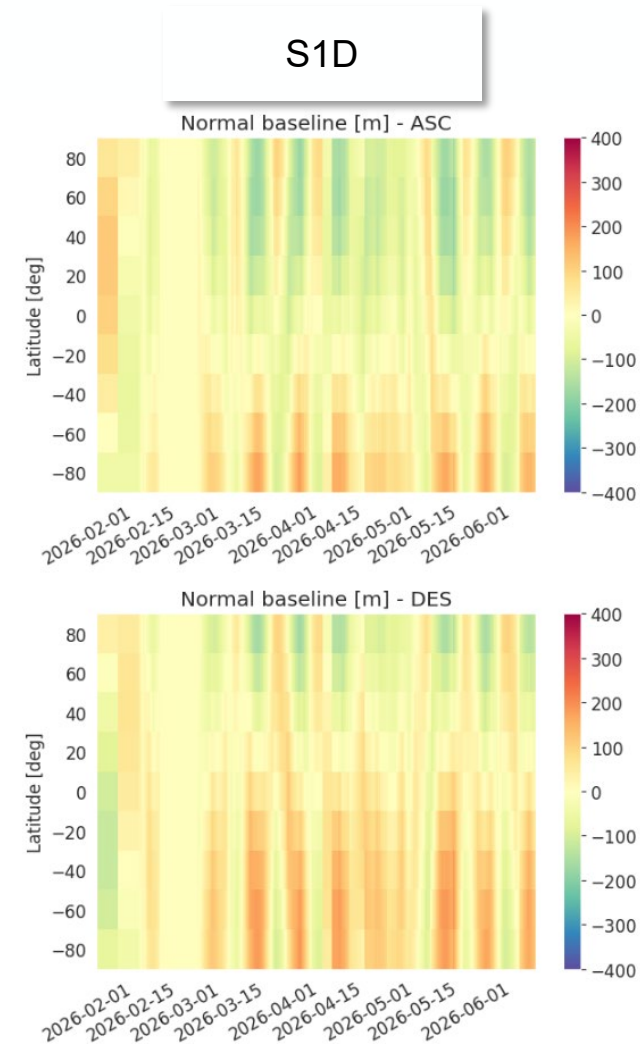


Instrument health is checked via different monitoring:

- Error matrices (Antenna Status)
 - Instrument Noise
 - Instrument Temperature
 - PG gain and phase
 - Doppler
 - Baselines and Burst Sync
-
- Due to an anomaly in the initial S1C reference orbit, S1C ground track was about 460m shifted w.r.t. to S1A ground track during IOC (issue observed at the end of IOC activities and by early users)
 - S1C vs S1C baselines unaffected
 - S1C vs S1A presented a shift in addition to the effects of currently relaxed S1A tube
 - Correction applied by flight dynamics on 21st of May 2025
 - Monitoring reference cycle selected as cycle #19 (from 03/06), marking the correction



- Error matrices (Antenna Status)
- Instrument Noise
- Instrument Temperature
- PG gain and phase
- Doppler
- **Baselines** and Burst Sync



Instrument Performance: Burst synchronization

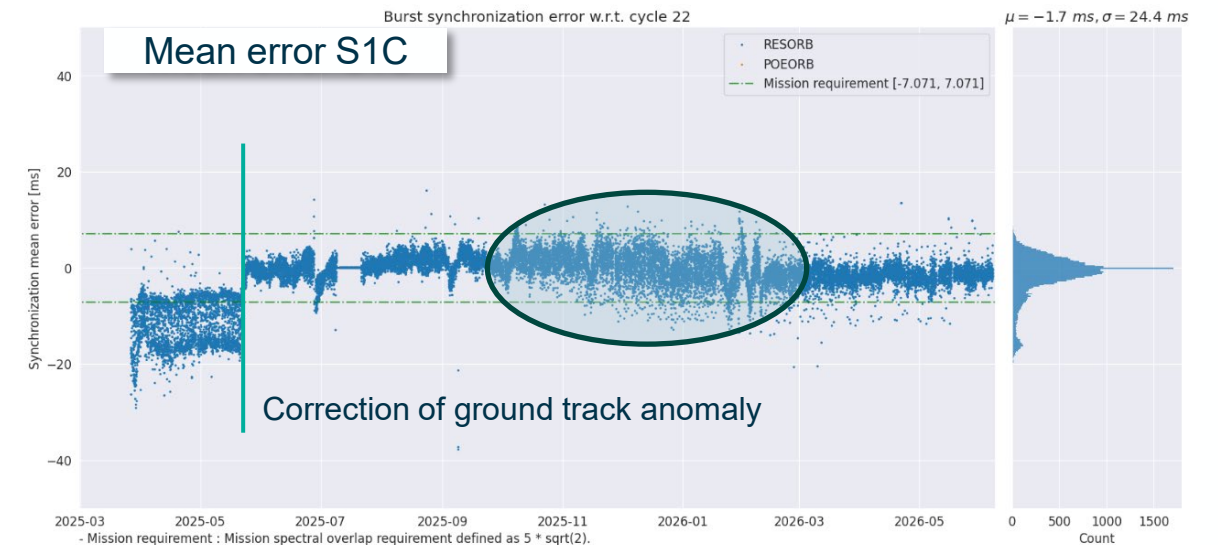
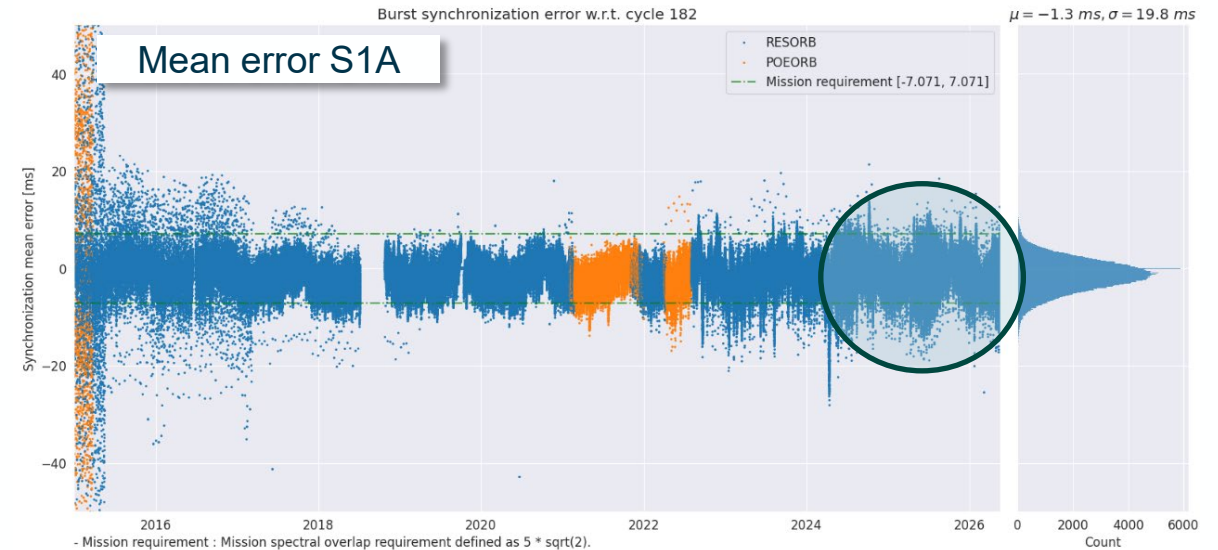


Instrument health is checked via different monitoring:

- Error matrices (Antenna Status)
- Instrument Noise
- Instrument Temperature
- PG gain and phase
- Doppler
- Baselines and Burst Sync

S1A: the impact on burst sync due to orbital tube degradation is observed as expected, with a degradation in the average DT error resulting from the reduced along-track baseline control

S1C: burst synchronization error is within requirements. Analysis w.r.t. reference cycle shows degradation in winter. This is found to be associated to varying orbit duration over the year, as expected



Instrument Performance: Burst synchronization

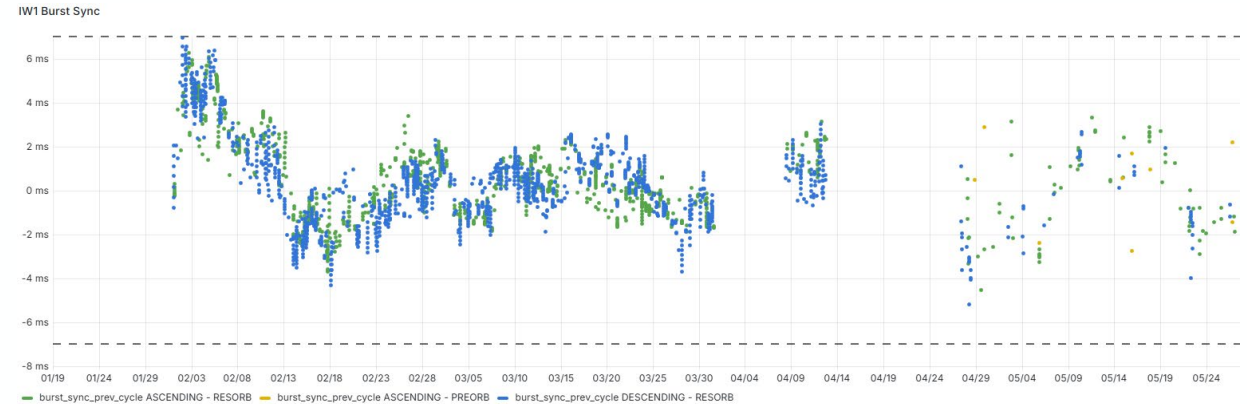
Instrument health is checked via different monitoring:

- Error matrices (Antenna Status)
- Instrument Noise
- Instrument Temperature
- PG gain and phase
- Doppler
- Baselines and Burst Sync

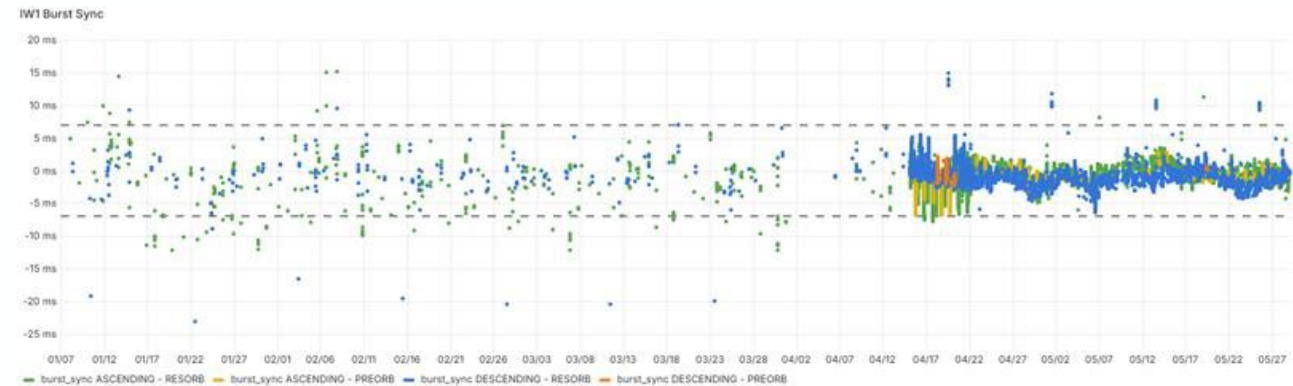
S1D: burst synchronization error is within requirements since the launch. Analysis w.r.t. reference cycle shows reduced number of points due to different acquisition plans in IOC -> new ref cycle number 22 starting at 2026-04-24T17:59:45

S1D vs S1C: burst synchronization error is within requirements since the launch

Mean error S1D



Mean error S1D vs S1C



Instrument Performance: Spectral overlap for S1D

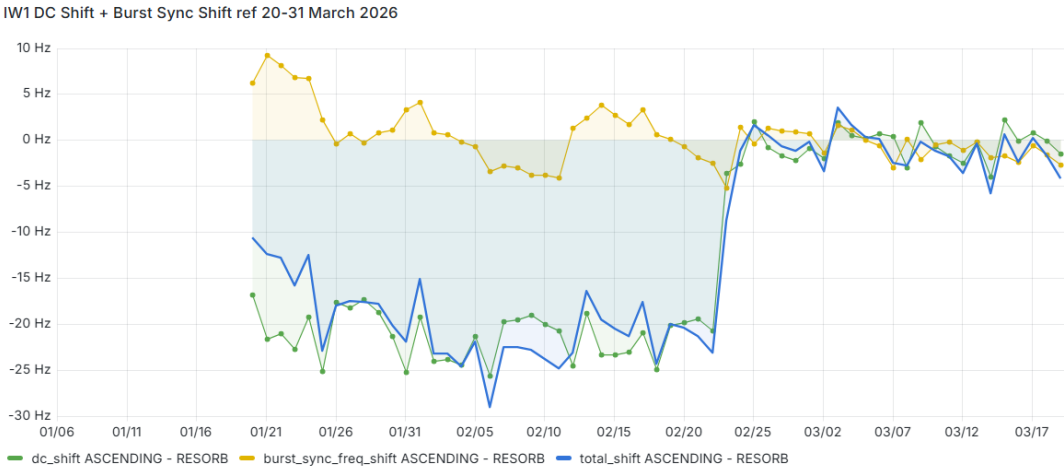
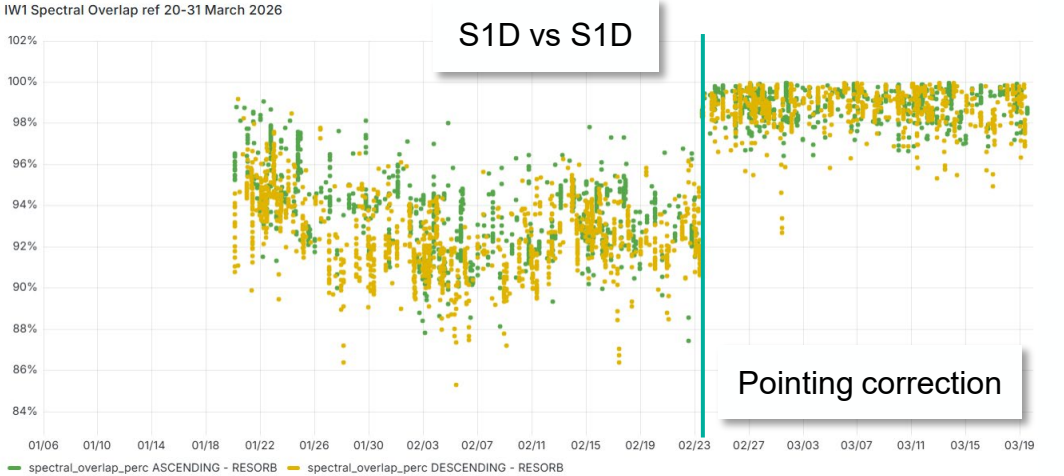


Instrument health is checked via different monitoring:

- Error matrices (Antenna Status)
- Instrument Noise
- Instrument Temperature
- PG gain and phase
- Doppler
- Baselines and Burst Sync
- Spectral Overlap

The spectral overlap is the combination of the effect of the burst synchronization error and of the difference in the DC between the considered acquisitions. The two effects can either compensate each other and result in a high spectral overlap or go in the opposite direction reducing the spectra overlap.

For the S1D vs S1D spectral analysis a reference cycle at the end of March 2026 was selected (20-31 March), in order to be able to confirm a very high spectral overlap (close to 100%) after the 23rd of February



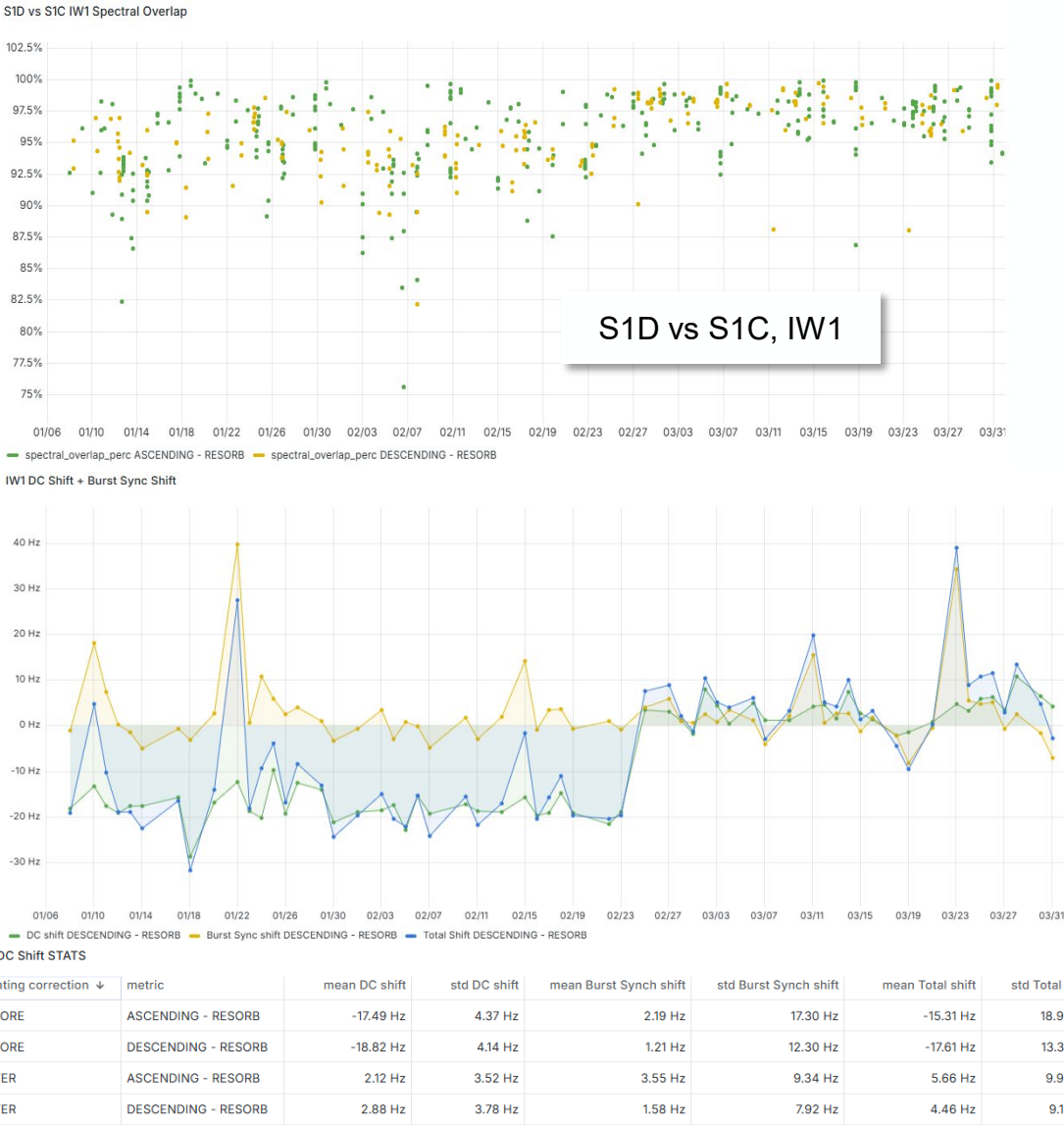
IW1 DC Shift STATS							
pointing correction	metric	mean DC shift	std DC shift	mean Burst Sync shift	std Burst Sync shift	mean Total shift	std Total shift
BEFORE	DESCENDING - RESORB	-23.95 Hz	4.22 Hz	0.62 Hz	4.11 Hz	-23.33 Hz	5.84 Hz
	ASCENDING - RESORB	-21.49 Hz	4.58 Hz	1.98 Hz	3.87 Hz	-19.51 Hz	6.20 Hz
AFTER	DESCENDING - RESORB	-2.58 Hz	3.75 Hz	0.30 Hz	2.14 Hz	-2.28 Hz	4.33 Hz
	ASCENDING - RESORB	-0.77 Hz	3.72 Hz	-0.24 Hz	1.71 Hz	-1.02 Hz	3.86 Hz



Instrument health is checked via different monitoring:

- Error matrices (Antenna Status)
- Instrument Noise
- Instrument Temperature
- PG gain and phase
- Doppler
- Baselines and Burst Sync
- Spectral Overlap

The same effect is observed when the cross-sensor spectral overlap is monitored w.r.t the S1C ref. cycle in 03-15 June 2025.



Instrument Performance: Spectral overlap for S1C

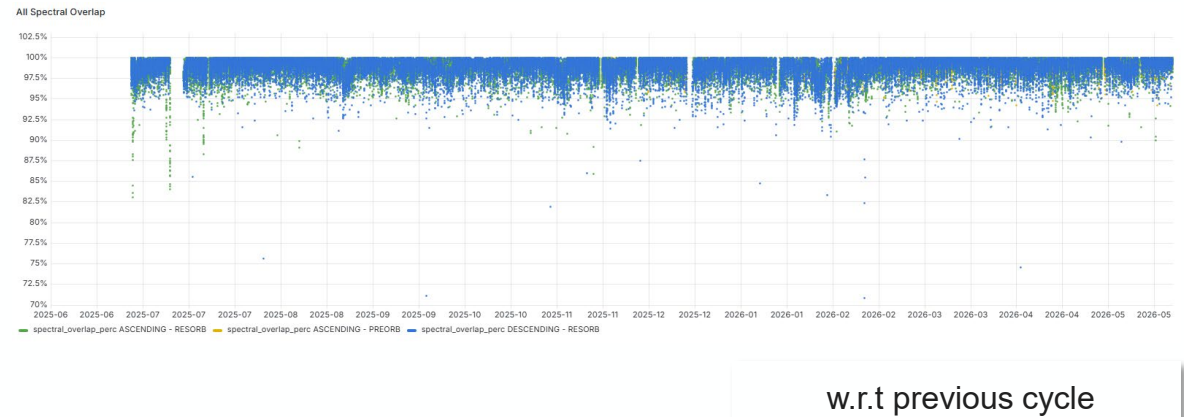
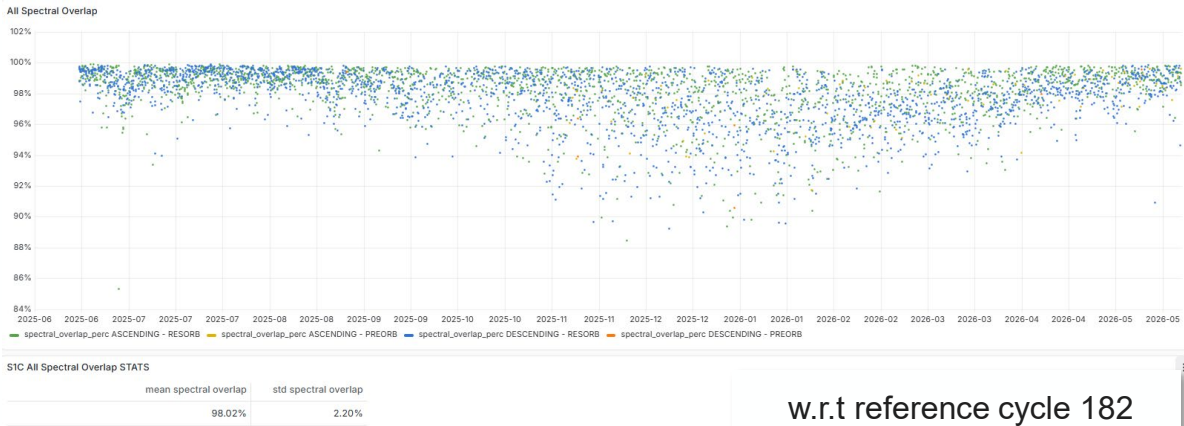


Instrument health is checked via different monitoring:

- Error matrices (Antenna Status)
- Instrument Noise
- Instrument Temperature
- PG gain and phase
- Doppler
- Baselines and Burst Sync
- Spectral Overlap

For the S1C vs S1C spectral analysis a reference cycle at the end of June 2025 was selected. For this reason, a seasonal behavior is expected

S1C vs S1C



L1 Quality: RFI impact

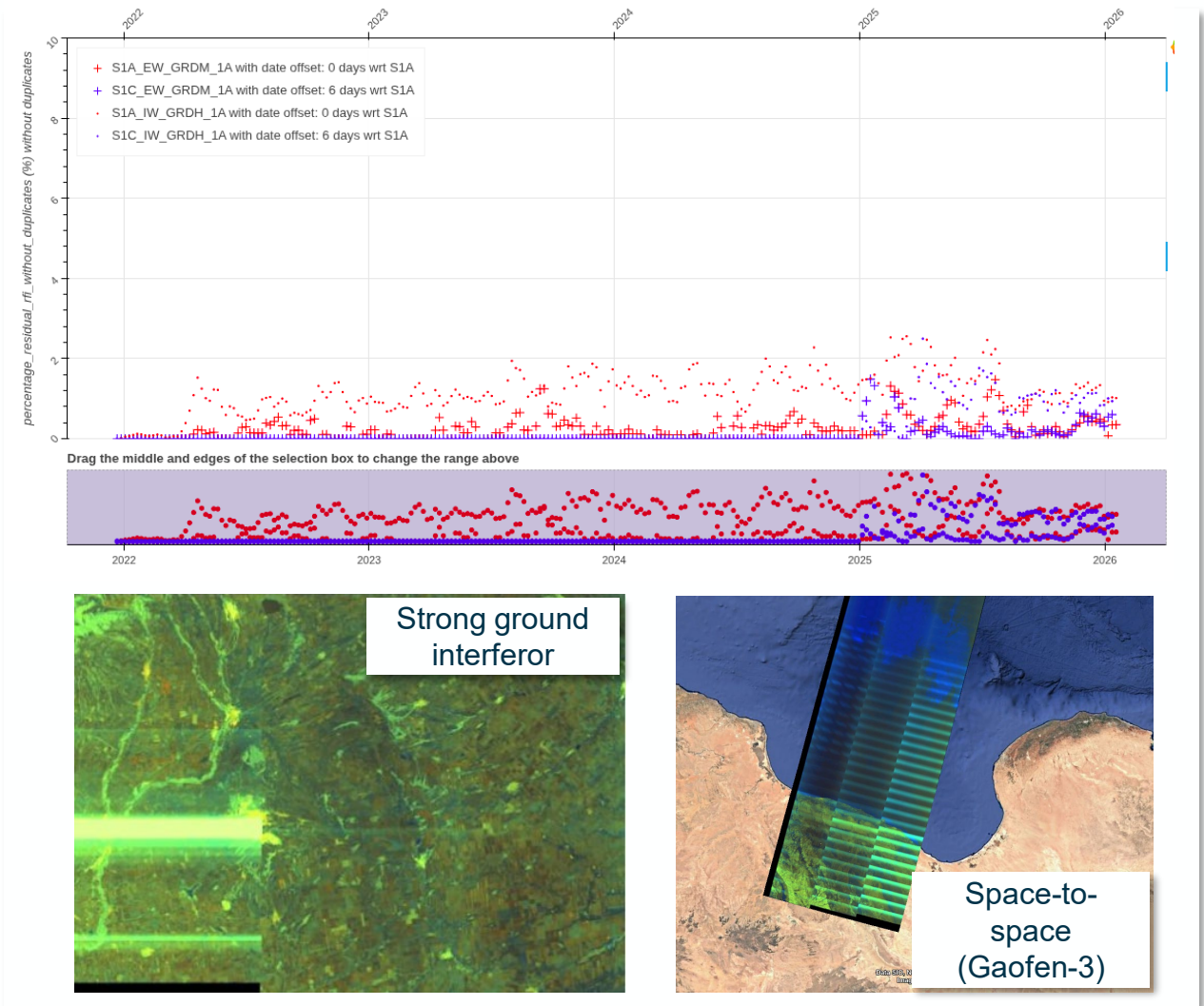
Radio Frequency Interferences (RFI) are

- Pre-screened using noise/rank pulses
- (Attempt of) mitigation if pre-screening recognizes RFI

RFI mitigation might be ineffective if

- RFI occupies a lot of the spectrum
- RFI not well capture in statical time/frequency domain data checks or
- RFI missed in noise/rank pulses
 - S1C currently using only noise, leading to reduced pre-screening statistics
 - Residual RFI still comparable

Number of RFI residuals slightly increased in 2025, and correspond to increase of “difficult” RFIs over specific areas. Reduction observed from Q4. *Note: results from QL inspection, Quality Disclaimer routinely published in <https://sar-mpc.eu/disclaimers/>*



Extended Timing Annotation Dataset for S-1 SAR data

Gridded corrections (~200m) in SAR slant range and azimuth

Tropospheric path delay

Ionospheric path delay

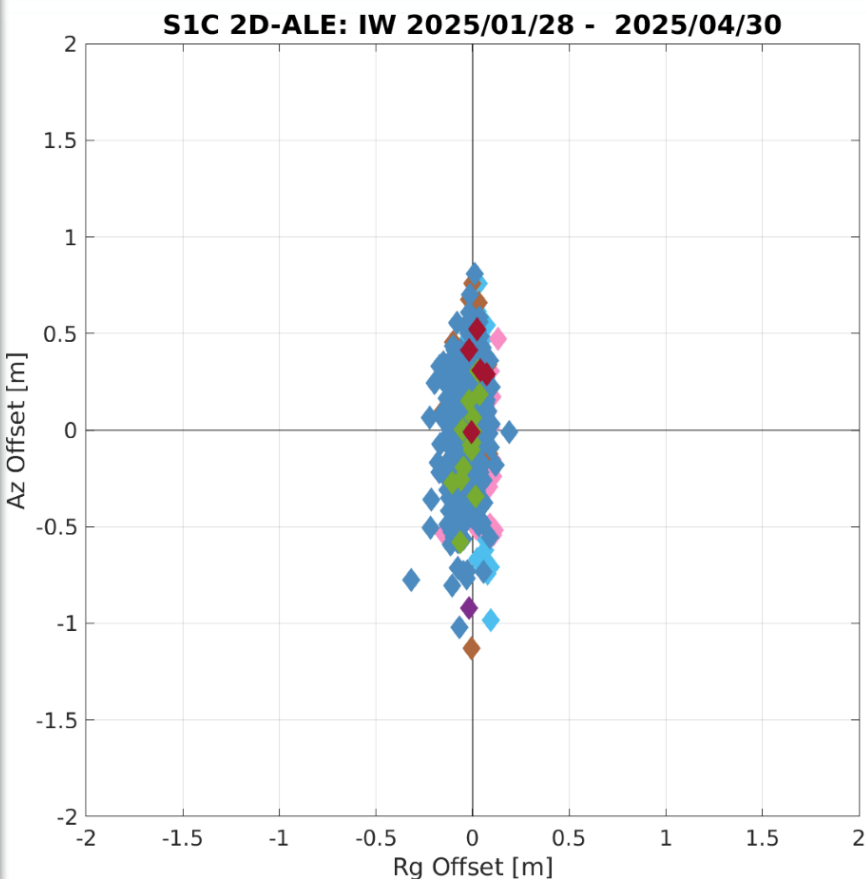
Solid Earth tides

S-1 system corrections

ETAD products available in CDSE (starting from July 2023). Full archive available for S1C/S1D

Can be used to improve geolocation of SLC products and support InSAR

Decimeter Geolocation Error after correction with ETAD layers



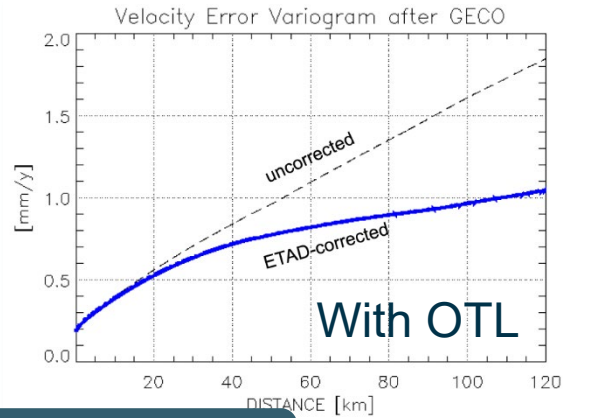
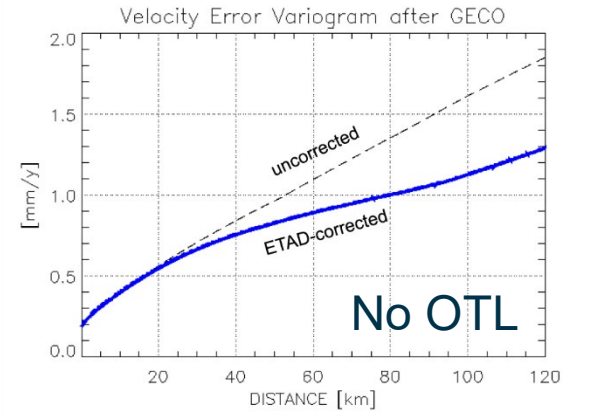
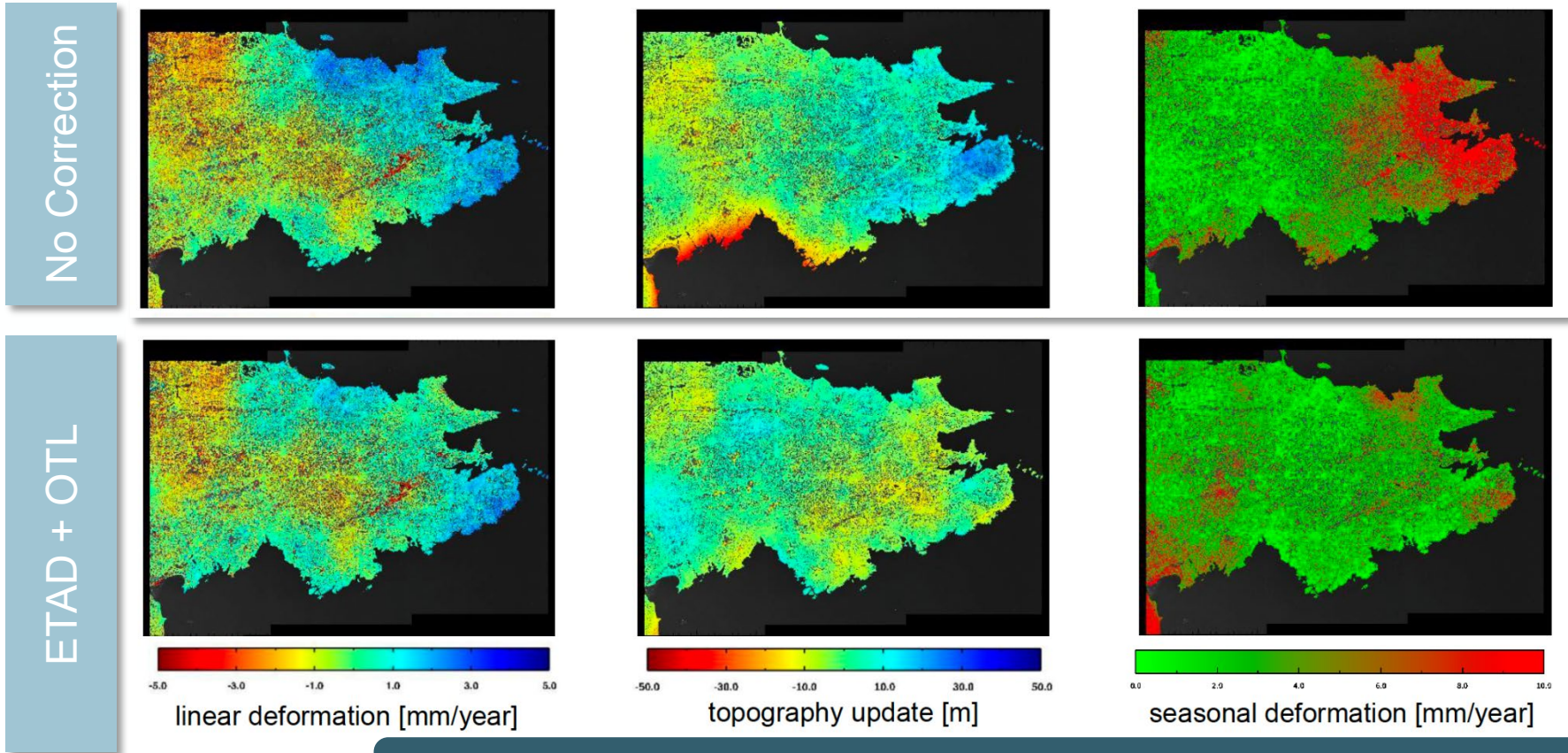
- BKG - WTZ
- FGI - MET
- GA - SURAT
- GA - YAR
- JPL - OKL
- JPL - ROS

ETAD can be used to bring geolocation accuracy to centimeter/decimeters levels, demonstrating high geolocation accuracy for S1A and S1C, and to support InSAR

Site	Rg ALE [m]	Az ALE [m]
All	-0.022 ± 0.062	-0.017 ± 0.283
BKG - WTZ	-0.020 ± 0.041	-0.085 ± 0.233
FGI - MET	-0.010 ± 0.035	0.027 ± 0.409
GA - SURAT	-0.038 ± 0.065	-0.019 ± 0.288
GA - YAR	0.022 ± 0.037	0.304 ± 0.199
JPL - OKL	0.024 ± 0.045	-0.040 ± 0.216
JPL - ROS	-0.033 ± 0.048	0.009 ± 0.247
UCA - OCA	0.024 ± 0.044	-0.032 ± 0.548

S-1 L1 Quality and Product Evolution: ETAD

New: **Tropospheric gradient** and **ocean tidal loading** layers to further support InSAR as of 24/06/2025



Timeliness reduced from 21 to 7 days since last Fringe

Sentinel-1 IPF 2024-2026 Updates



IPF 3.80 (19/04/2024)

L2: support to S1C/S1D

L2: Introduction of AUX_ML2 in support of machine learning algorithms

IPF 3.90 (04/11/2024)

L2: Update of TotalHS implementation in OSW

IPF 3.91 (31/01/2025)

IPF 3.92 (09/05/2025)

L1: correction of reference frame convention for elevation angle computation

IPF 4.00 (15/10/2025)

L1: Delta-K correction

L2: introduction of TOPS xSpectra

IPF 4.01 (03/12/2025)

L1: fixed robustness issue with Delta-K correction

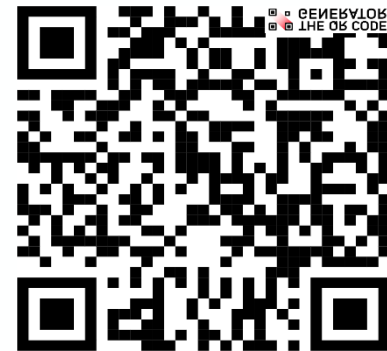
IPF 4.02 (16/12/2025)

L1: Improve management of chirp parameters

L2: improve robustness

IPF 4.03 (02/02/2026)

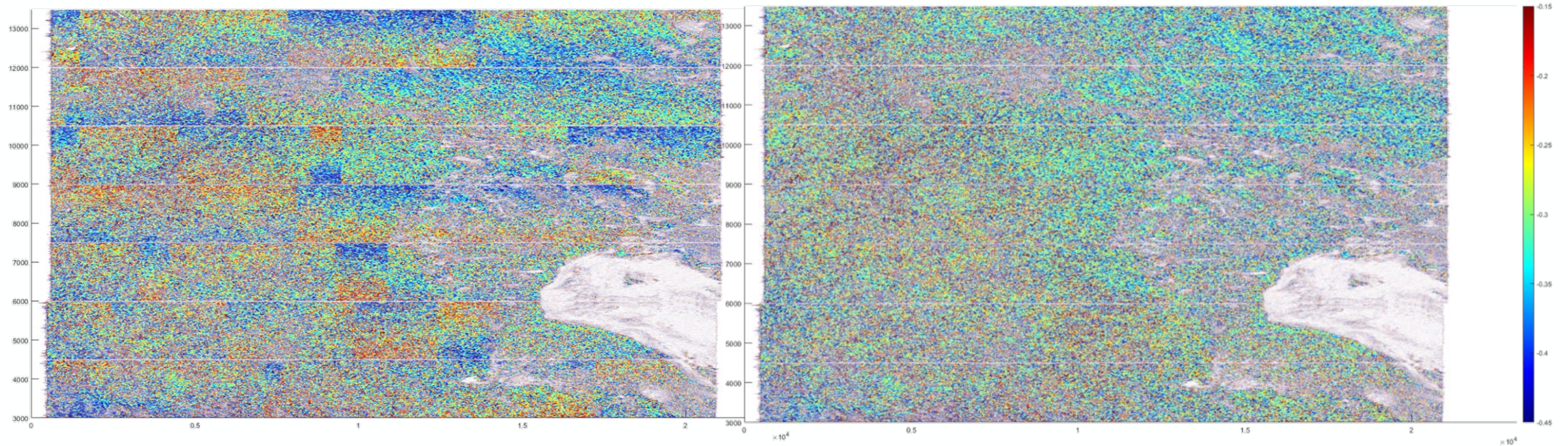
L2: improve configuration of parallel processing for OSW on WV



Fix on Delta-K Processing (IPF 004.00)

Before correction

After correction



IPF 004.00 introduces a correction of a long-standing issue causing the inclusion of a dispersive range artefact during focusing, impacting results obtained via interferometric split spectrum processing

- Since the beginning of S1C IOC, an asymmetric range IRF was observed over point targets
- The asymmetric IRF was due to a higher order phase term that was not compensated during range compression
- IPF and pulse parameters in AUX-INS file were updated for S1C and S1D to allow the correction of the asymmetry
- The correction was effective and the IRF asymmetry is no longer observed
- Currently a small phase residual is still observed for S1C that introduces phase jumps between sub-swaths when split spectrum technique is applied to cross-sensor data (S1C vs S1A or S1C vs S1D)
- The issue is not observed for S1D (i.e. S1D vs S1A)
- Definition of new pulse parameters for S1C (analysis on-going) could allow to fix the issue in the future

- Note: the split spectrum technique magnifies the observed phase jumps -> an asymmetry in the range spectrum phase of 0.5 degrees resulting in an ionospheric phase jump of 50 degrees

SENTINEL-1

Quality Disclaimer

No. 379



Title:
S1D Time Shift

Description:
Corruption of the SAR instrument internal clock that was shifted by 0.18s following a SAR instrument reset occurring on 2026-05-29T23:57:56.912

The products are impacted inter alia by:

- a global geometric shift in the azimuth direction of around 1250 m on all product types
- a shift in Doppler centroid

Other potential quality degradations are under investigation.

All SAR products acquired during the period and then processed are impacted, including:

- all RAW products
- all SLC and GRD products
- all OCN products

ETAD products from the impacted period are not yet produced. The impact will be assessed pending definition of potential data recovery approaches and the production of the data.

The list of impacted products is provided at the end of this report.

Degradation types:

☐ COMPLETE_PRODUCT_DEGRADATION	☐ DEGRADED_PHASE
☐ DEGRADED_BURST_ID	☐ DEGRADED_PLATFORM_POINTING
☐ DEGRADED_DENOISING_VECTORS	☒ DEGRADED_PRODUCT_GEOLOCATION
☐ DEGRADED_DOCUMENT_METADATA	☐ DEGRADED_PRODUCT_RADIOMETRY
☒ DEGRADED_METADATA	☐ DEGRADED_RADIOMETRIC_CALIBRATION
☒ DEGRADED_OCN_RADIAL_VELOCITY	☐ INTERFERENCE
☒ DEGRADED_OCN_SWELL	☐ MISSING_DATA
☒ DEGRADED_OCN_WIND	☐ NOT_QUALIFIED
☐ DEGRADED_ORBIT_CONTROL	☐ SLICE_PRODUCT_NON_CONCATENABLE
☐ DEGRADED_PERFORMANCE_INSTRUMENT_ANOMALY	☒ OTHER

Degradation percentage¹:

100%

The images are shifted by about 1400m (on average) in the azimuth direction

Percentage of impacted products²:

100%

All S1D products during the reported period are impacted.

Impacted products:

Platform:	☐ S-1A	☐ S-1B	☐ S-1C	☒ S-1D		
Acquisition mode:	☒ EW	☒ IW	☒ SM	☒ WV		
Product type:	☐ INS	☐ CAL	☐ PP1	☐ PP2	☐ ML2	☐ SCS

¹ Percentage of degradation of the data in the product (100% means that the product should be masked in the product catalogue)
² Percentage of impacted products is computed over the products identified by placing the conditions defined in the "Impacted products" and "Period of issue" sections.

All dates in the document are provided in UTC

1

Quality Disclaimers available at <https://sar-mpc.eu/disclaimers/>

Latest major quality issue encountered between 2026-05-29 16:03:13 and 2026-06-01 18:00:21 impacting S1D

Corruption of the SAR instrument internal clock that was shifted by 0.18s following a SAR instrument reset.

- Global shift of around 1250m in azimuth
- Loss of burst synchronisation with impact on InSAR applications

QD-379 on internal clock corruption



During the anomaly:

- Shift of around 1250 km in azimuth direction
- Drop of Doppler Centroid
- Loss of burst synchronisation making the TOPS products not suitable for InSAR applications

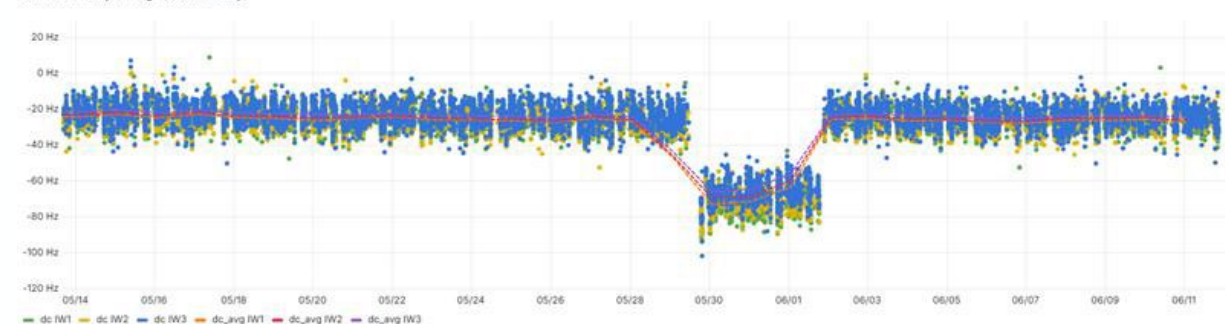
Only the shift azimuth shift can be compensated by reprocessing.

TOPS products are not usefull for InSAR Application (even by forcing bulk coregistration)

SM products could be used for InSAR after applying bulk coregistration

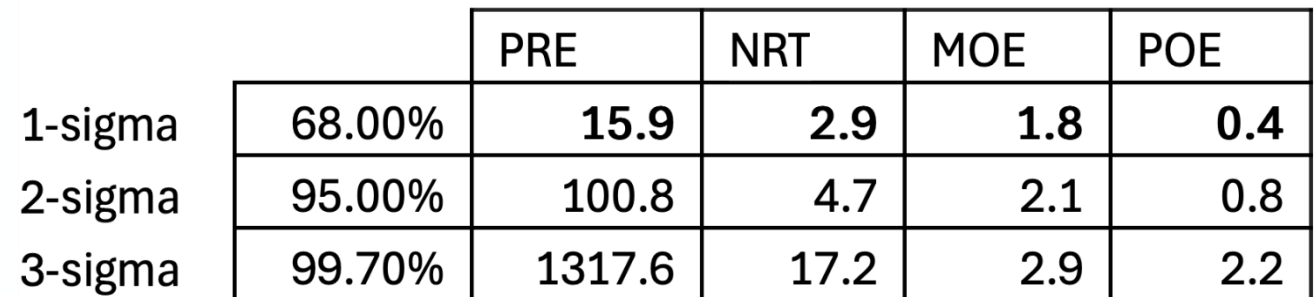
Time series of Doppler Centroid on S1D

IW All DC + Daily Average (over land only)



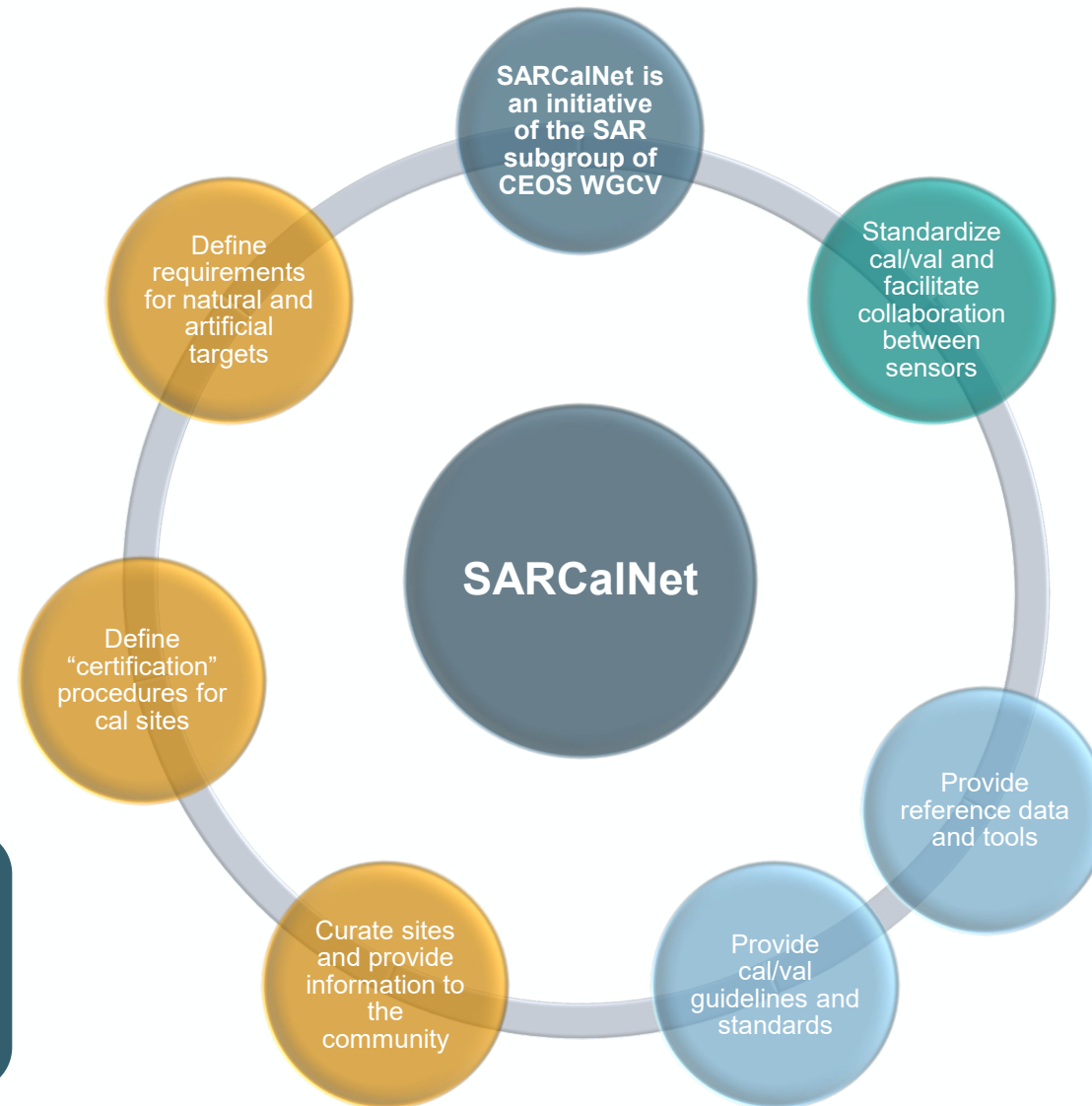
- AUX_PRE:** accuracy threshold 100 cm , 30min latency
- AUX_RES or NRT:** accuracy threshold 10cm, 45 min latency (previously 3h)
- (NEW) AUX_MOE:** accuracy threshold 5 cm, 30h latency
- AUX_POE:** accuracy threshold 5cm, 21 days latency

- It has similar accuracy and format as POE, but greatly reduced timeliness (**30h instead of 21 days**)
 - *Validation performed by MPC*
- It allows to reduce ETAD timeliness to around 7 days instead of 21 days (with TEC info as new bottleneck).
SETAP 3.0 will use the new orbit type



To provide ETAD products rapidly (latency is currently limited by POD orbit generation time); request to publish ETAD corrections and restituted orbits within 48 hours from the acquisition of the SAR image (side discussion after the session).





Fringe 21: ESA fostering mechanism for acknowledgement of sites with CRs/Transponders and their networking

Fringe 23: Define / provide test areas (supersites) together with SAR and auxiliary data sets for the cross-comparison of algorithms.

As a reminder...

Sentinel-1 Yearly Performance Reports

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Performance
Reports



S1 online



Quality
Disclaimers

