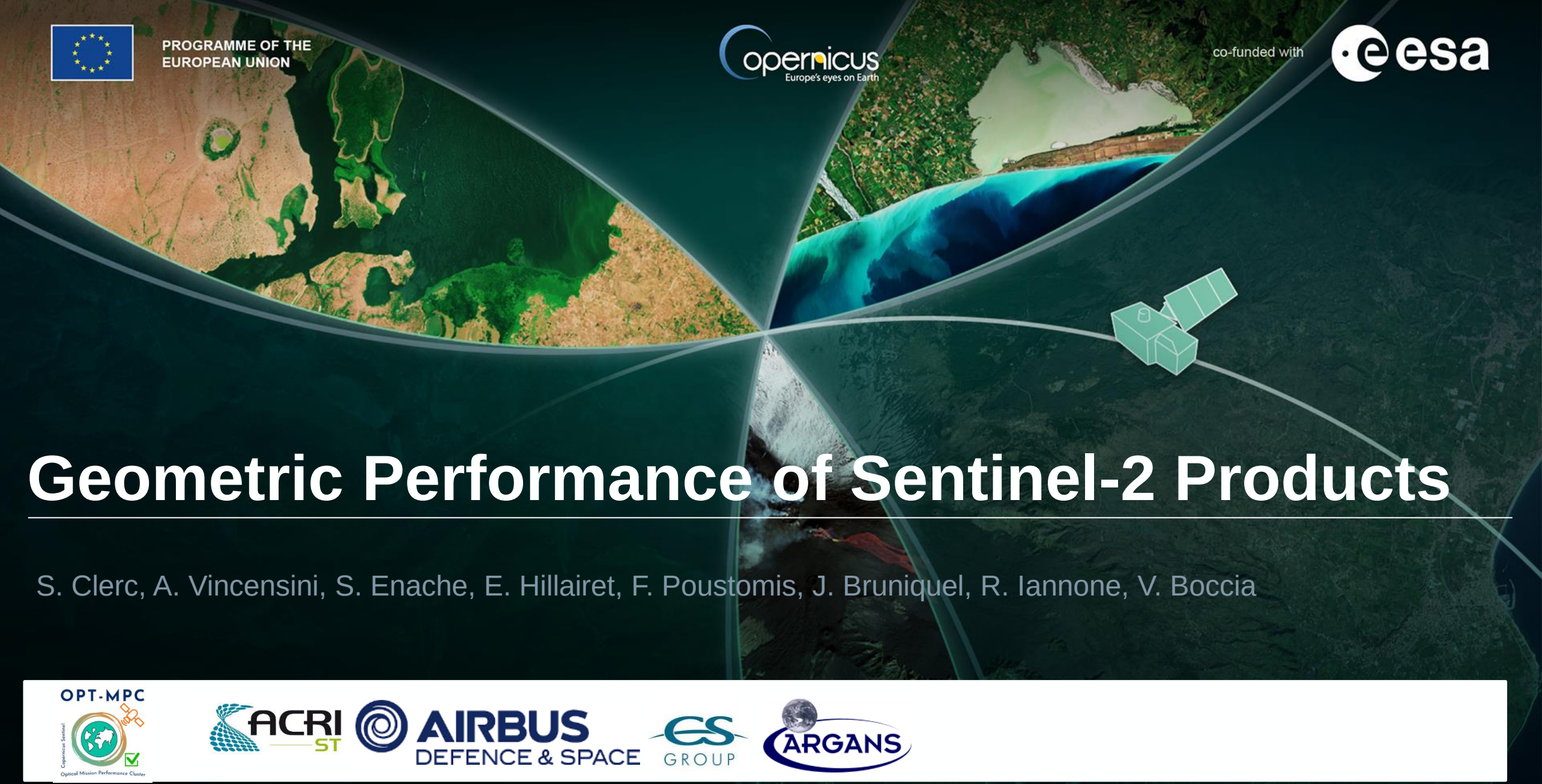


Geometric Performance of Sentinel-2 Products

S. Clerc, A. Vincensini, S. Enache, E. Hillairet, F. Poustomis, J. Bruniquel, R. Iannone, V. Boccia

OPT-MPC Optical Mission Performance Cluster
ACRI ST
AIRBUS DEFENCE & SPACE
ES GROUP
ARGANS

Outline

- Geometric refinement
  - Performance Status for Near Real Time and Collection 1 products
  - Open points
- Unrefined products
  - Improvement refinement success rate
  - performance of un-refined products
- Digital Elevation Model for orthorectification
  - Near Real Time and Collection 1 products
- Multi-spectral co-registration

Geometric refinement

Geometric refinement using the Global Reference Image (GRI) is activated since March 2021.

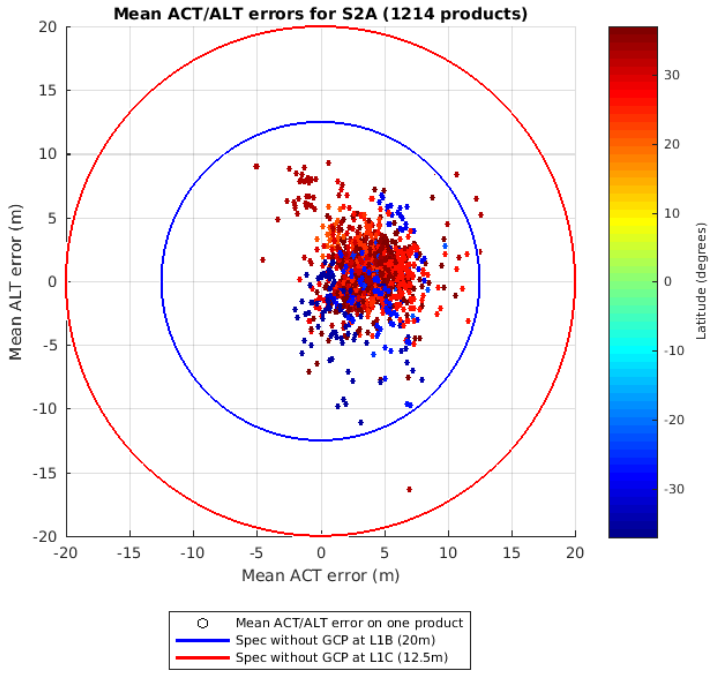
Collection 1 reprocessing will provide a uniform time series with geometric refinement

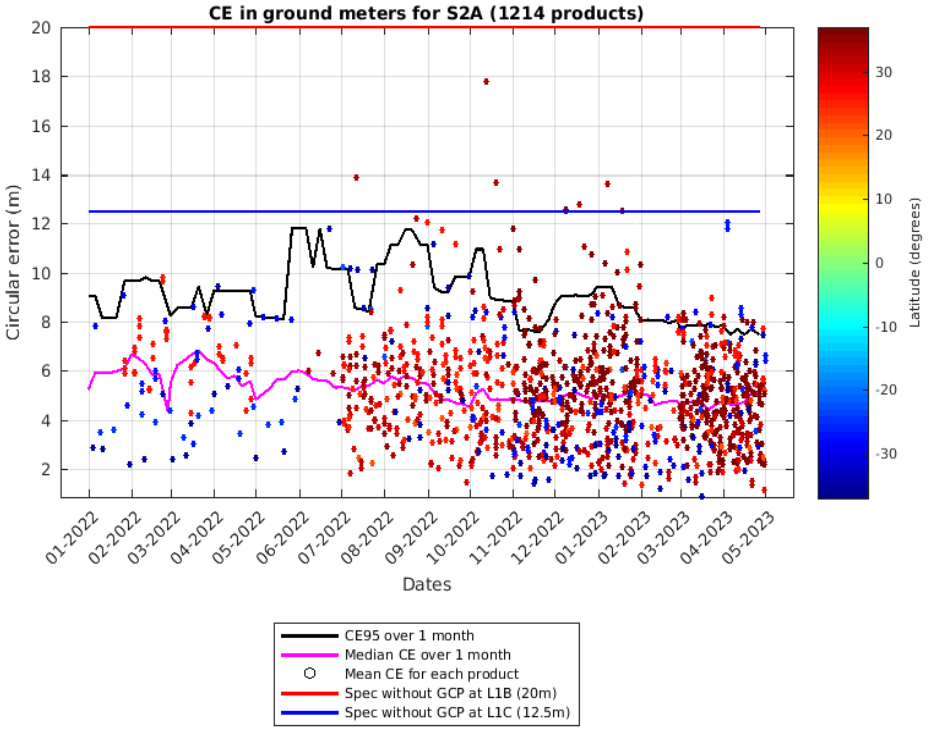
Performance assessment by MPC

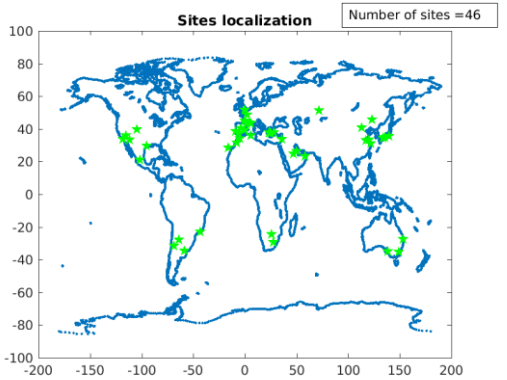
- Against reference Ground Control Points by Airbus
- Against the GRI by ACRI + multi-temporal performance
- For Near Real Time and Collection 1 products

Absolute geolocation performance of refined products

Sentinel-2A





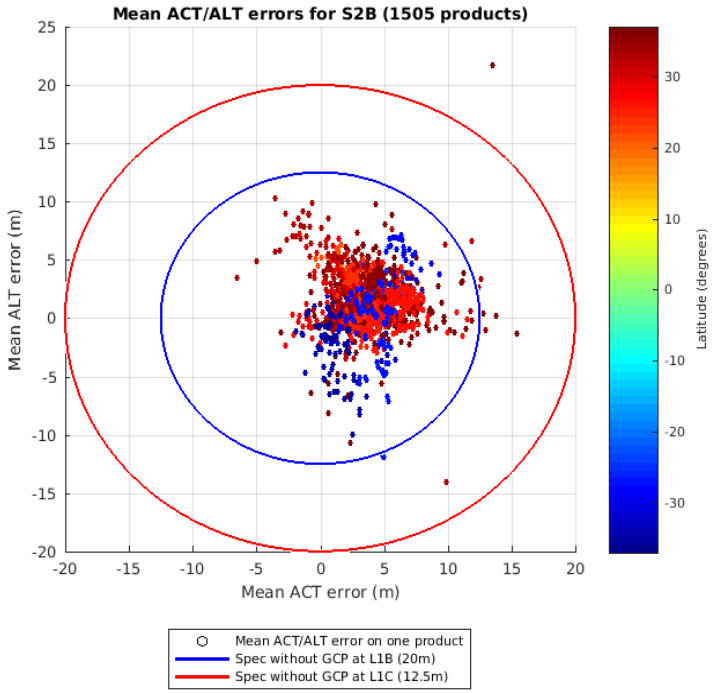


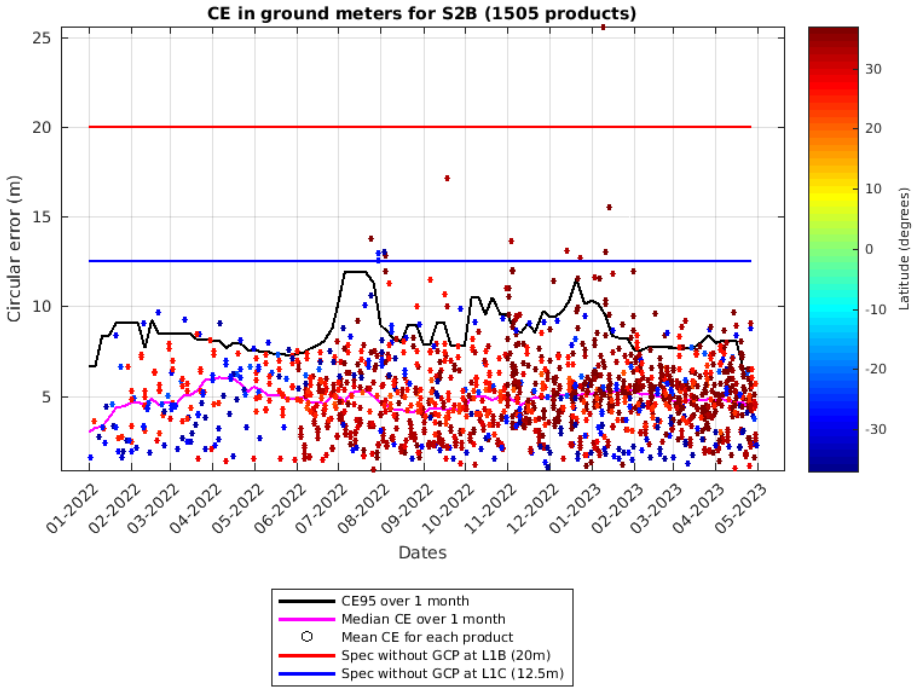
Mean ACT error (m)	3.69 m
Mean ALT error (m)	0.60 m
Mean circular error (m)	5.13 m

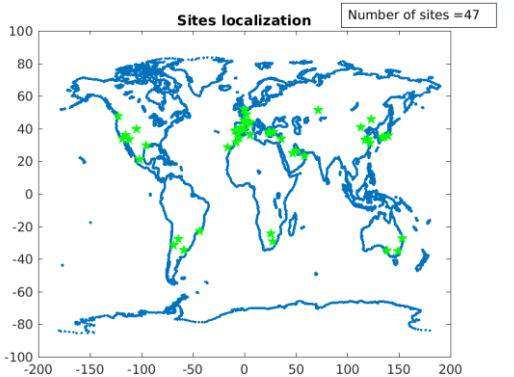
Std-dev of mean CE(m)	2.14 m
Circular error (m)	**9.08 m**
Mean Req. w/o GCP @95% (m)	20 m
Target with GCP @95% (m)	12,5 m

Absolute geolocation performance of refined products

Sentinel-2B







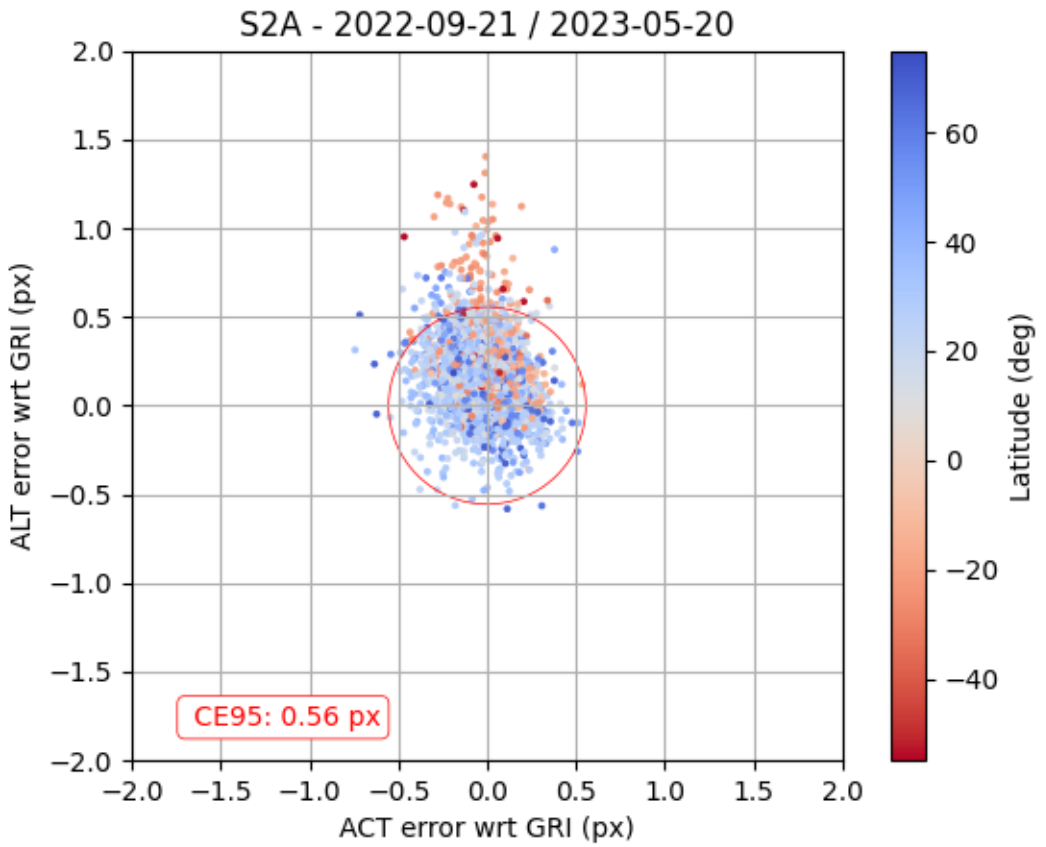
Mean ACT error (m)	3.59 m
Mean ALT error (m)	1.32 m
Mean circular error (m)	4.99 m

Std-dev of mean CE(m)	2.19 m
Circular error (m)	**8.60 m**
Mean Req. w/o GCP @95% (m)	20 m
Target with GCP @95% (m)	12,5 m

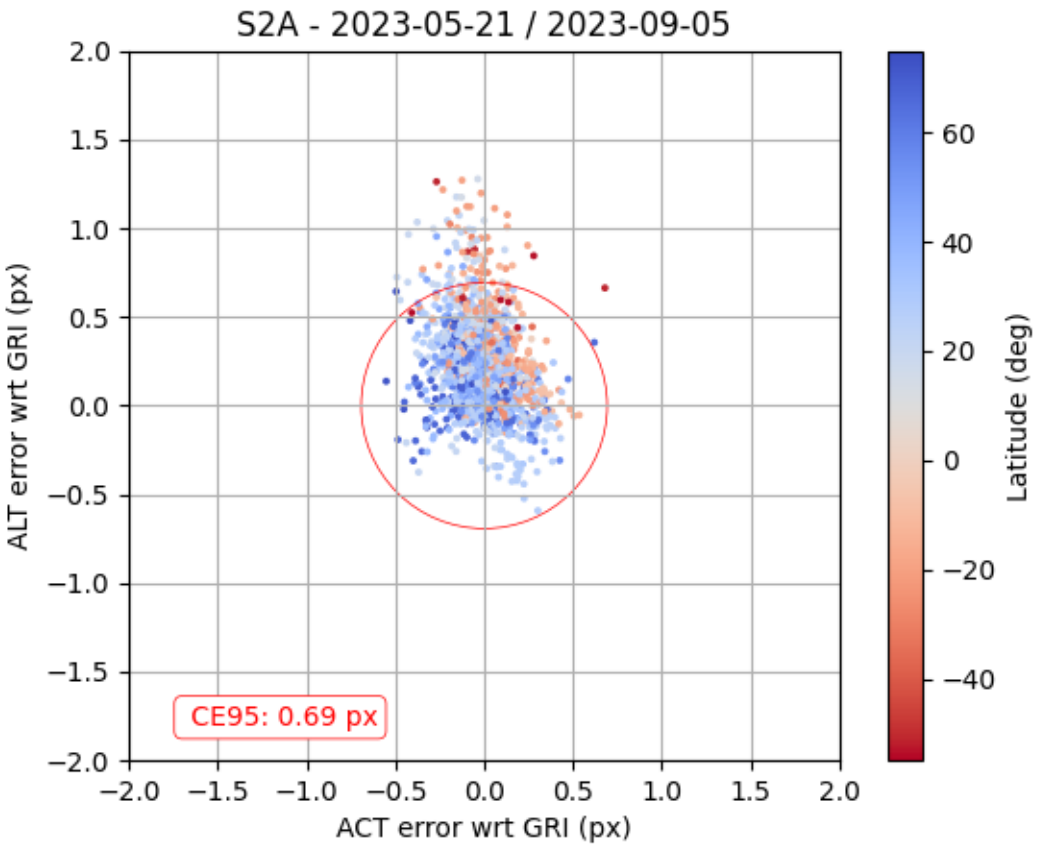
Co-registration with the GRI

Sentinel-2A: outliers with large ALT error, especially in Southern hemisphere

winter



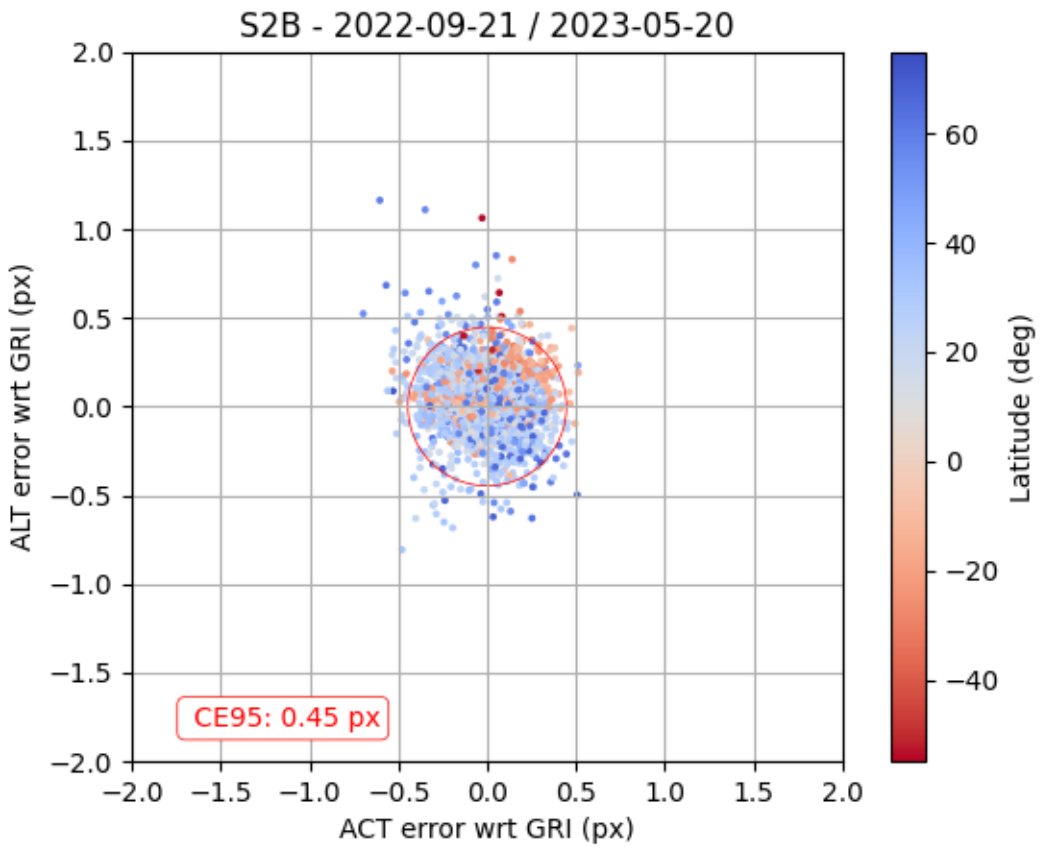
summer



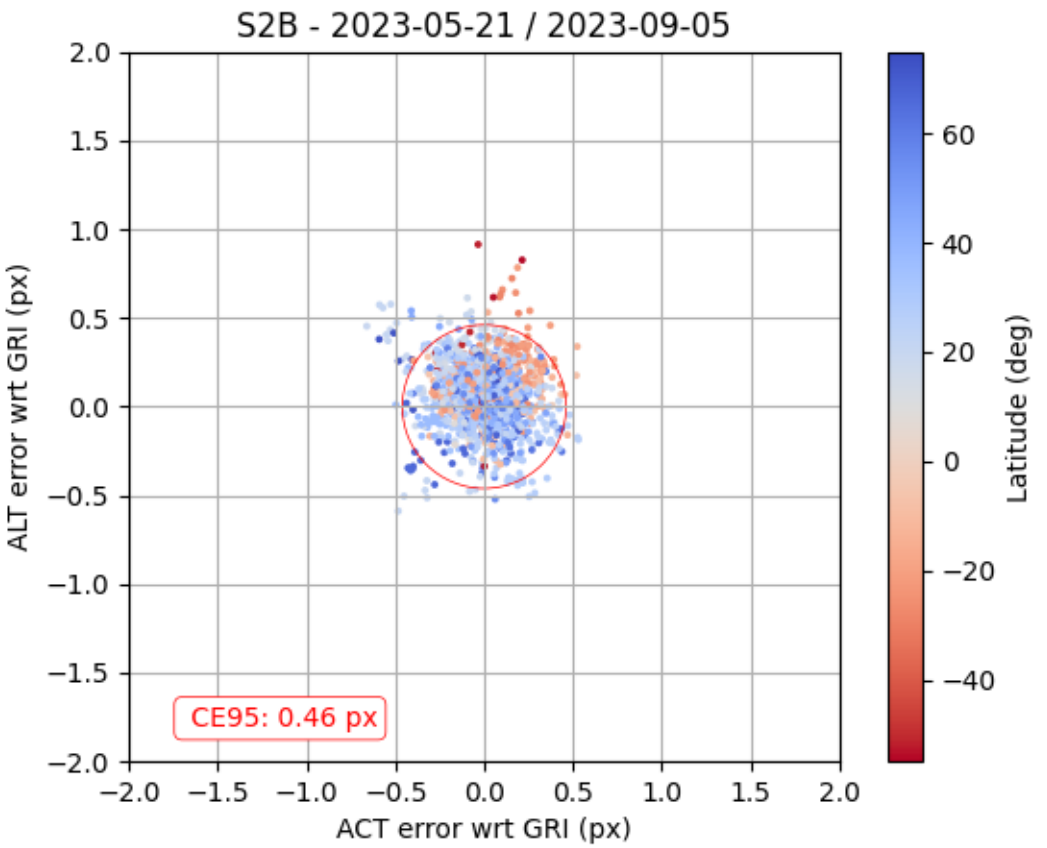
Co-registration with the GRI

Sentinel-2B: better and more stable performance

winter

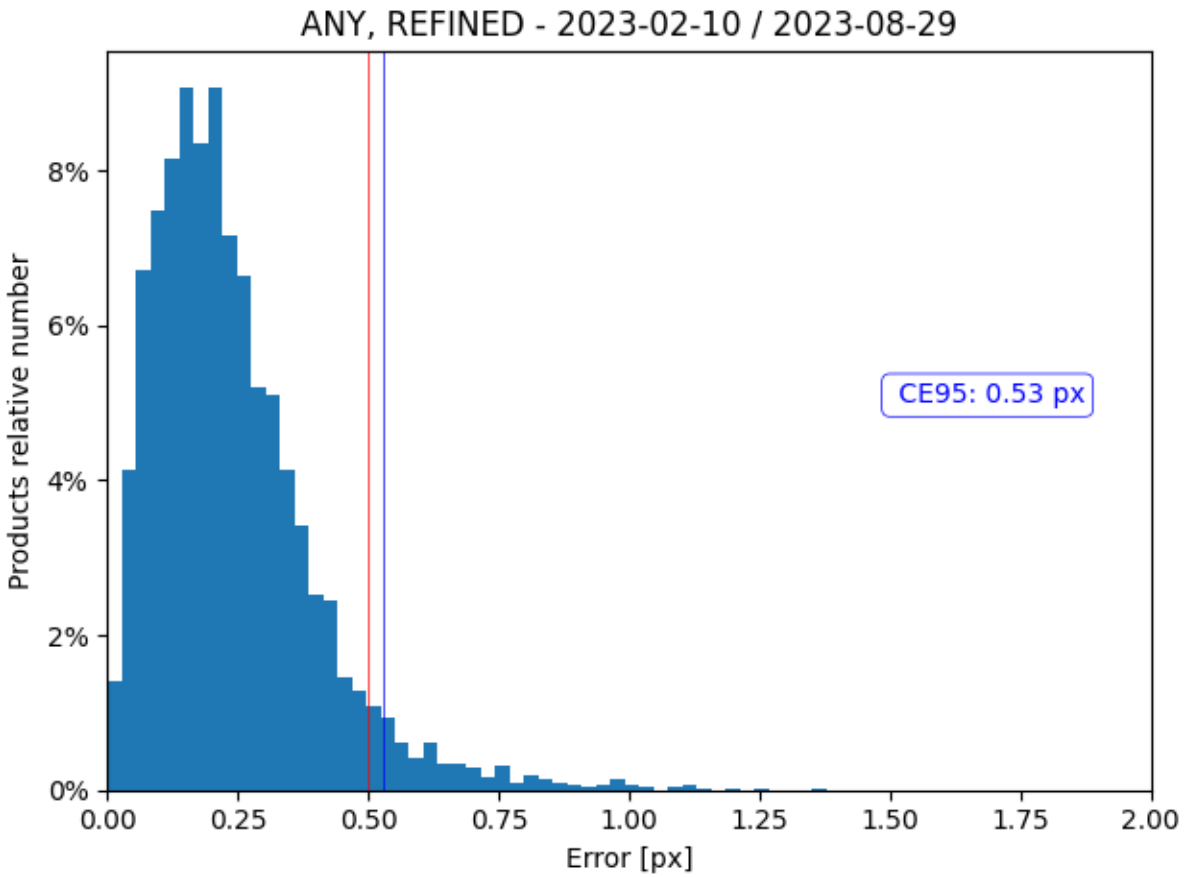


summer

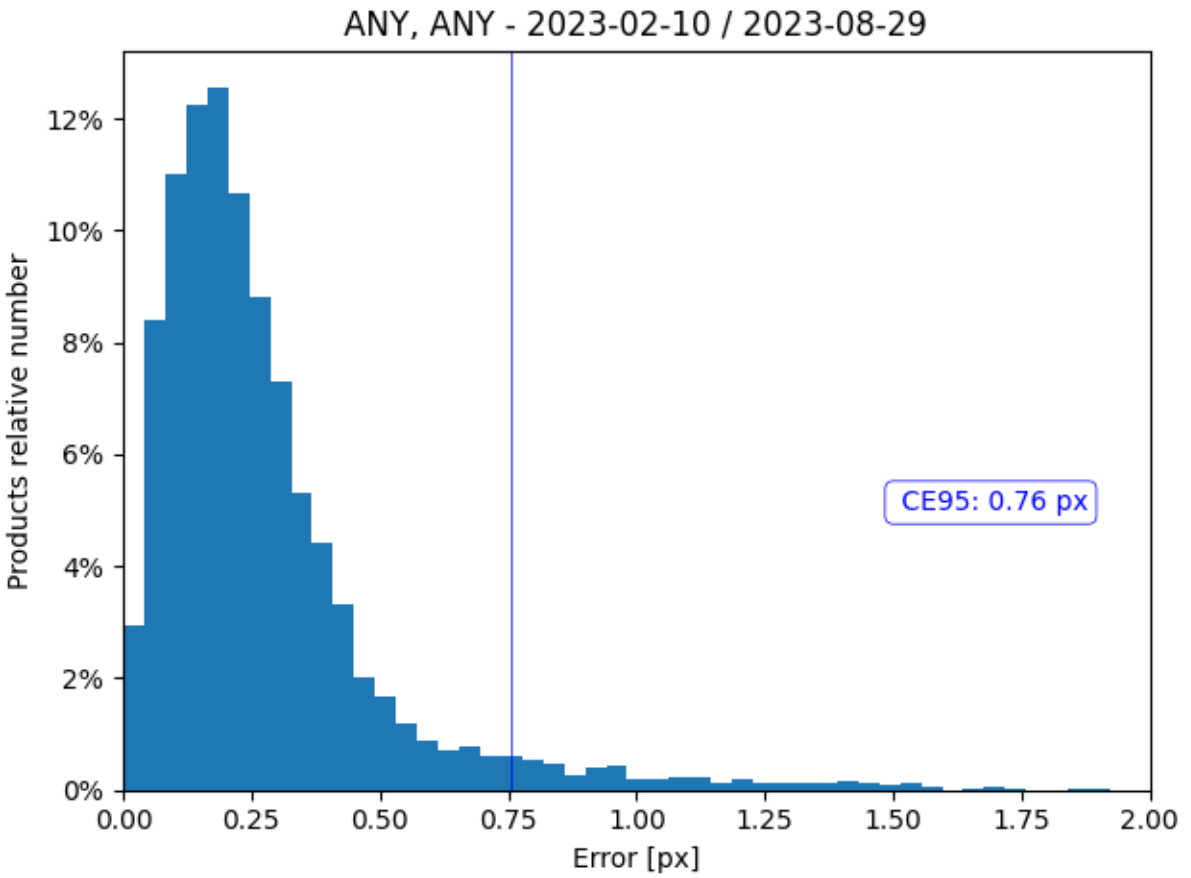


Multi-temporal performance

Co-registration between any pair of refined tiles

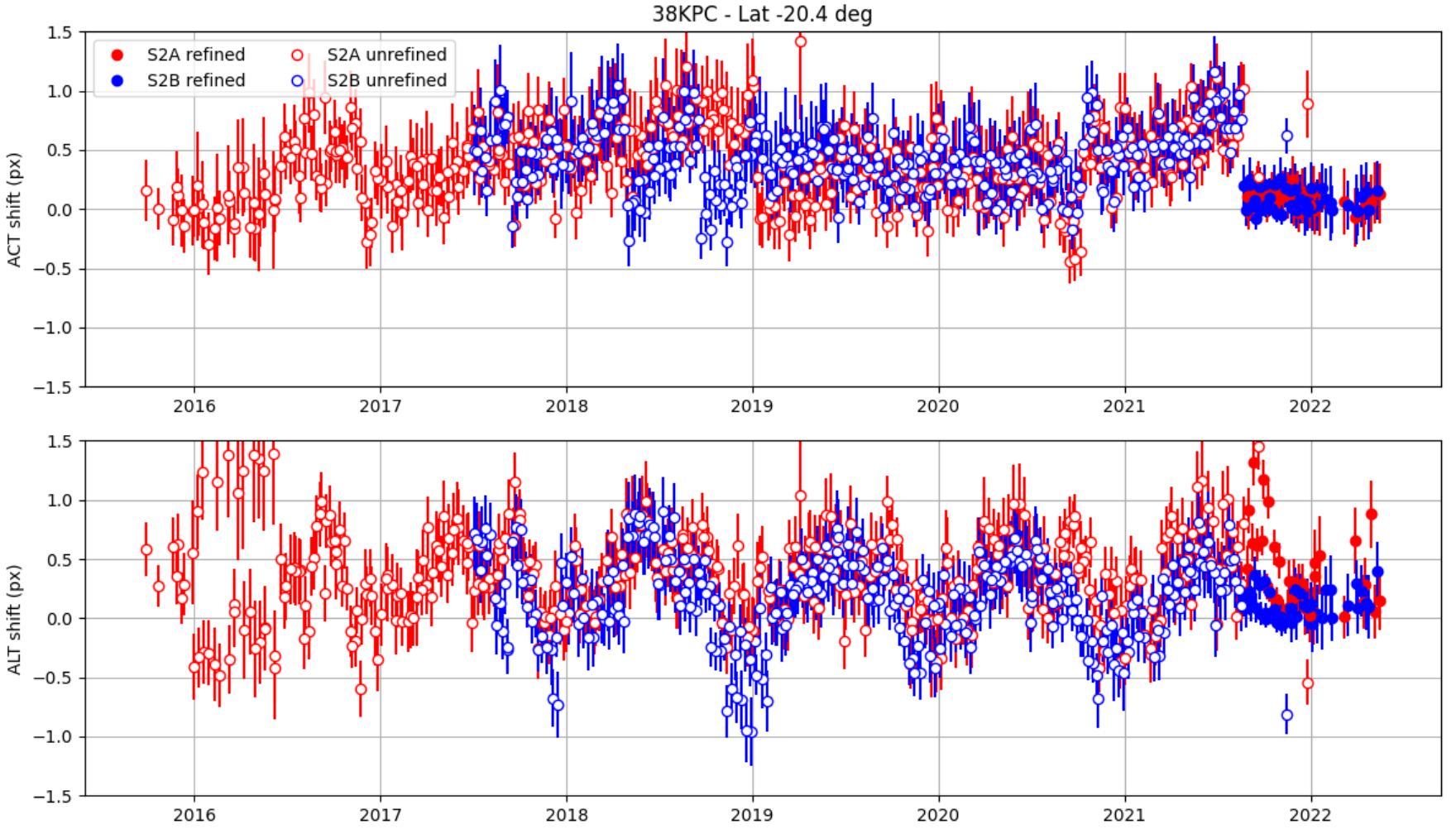


or any pair of tiles (refined or not)



Time series

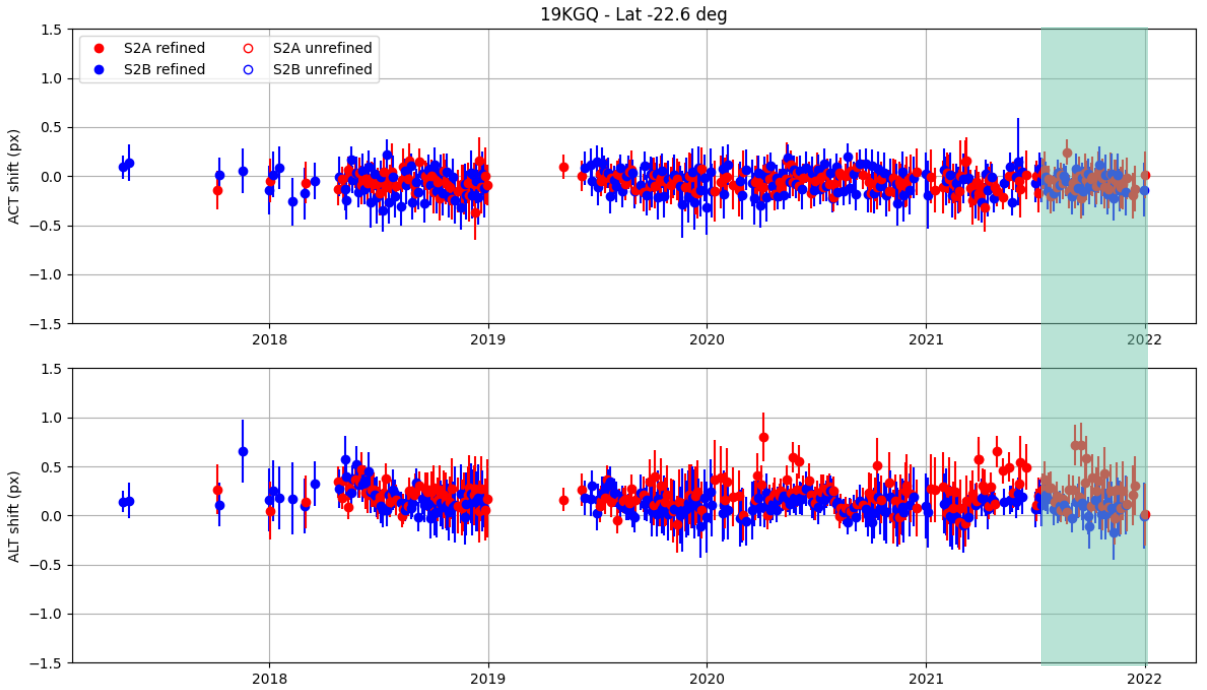
Pre-collection status: strong seasonal effects, jumps due calibration updates, S2A/S2B offsets



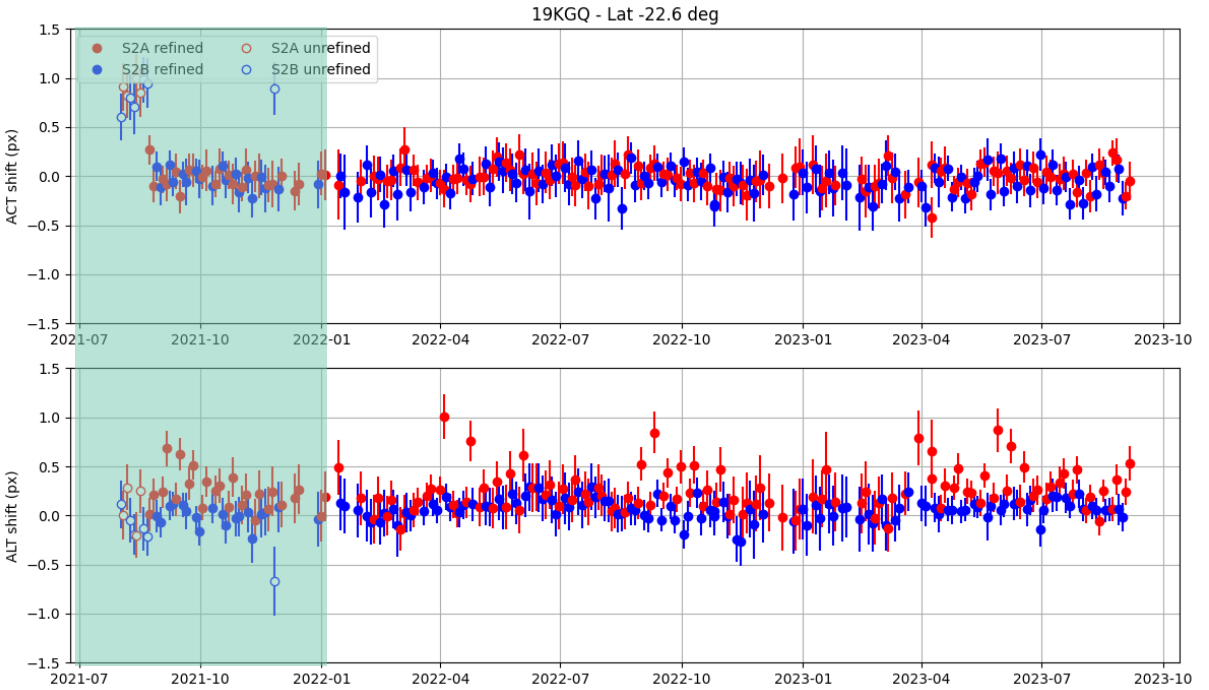
Time series

Collection-1 reprocessing: consistent performance over time

Collection 1 reprocessing (in progress)



Near Real Time production



Unrefined products

Unrefined products are still produced

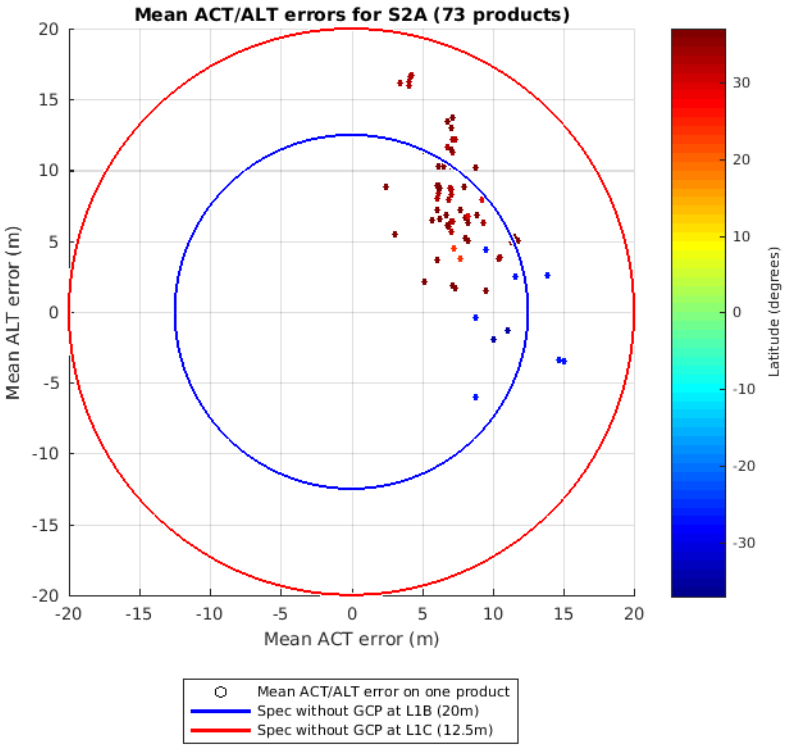
- In areas/orbits not covered by the GRI (small islands, Antarctica, some high latitude areas)
- In critical situations with few tie-points (due to cloud, snow, etc)

Critical situations are identified using empirical quality criteria

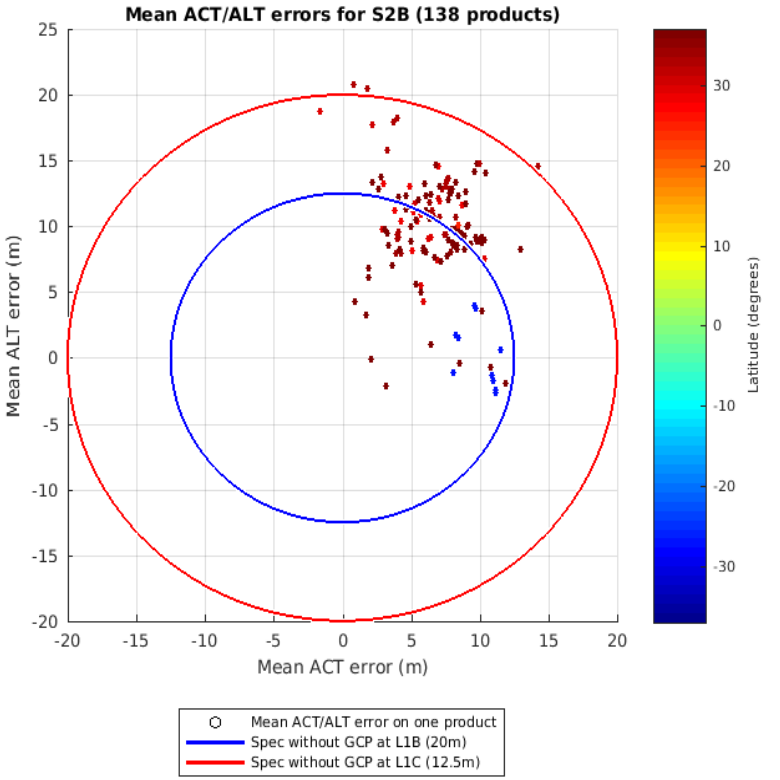
- number and density of tie-points, maximum estimated shift, large standard deviation…

Absolute Performance of unrefined products

Low number of products available for analysis, mostly at high latitudes



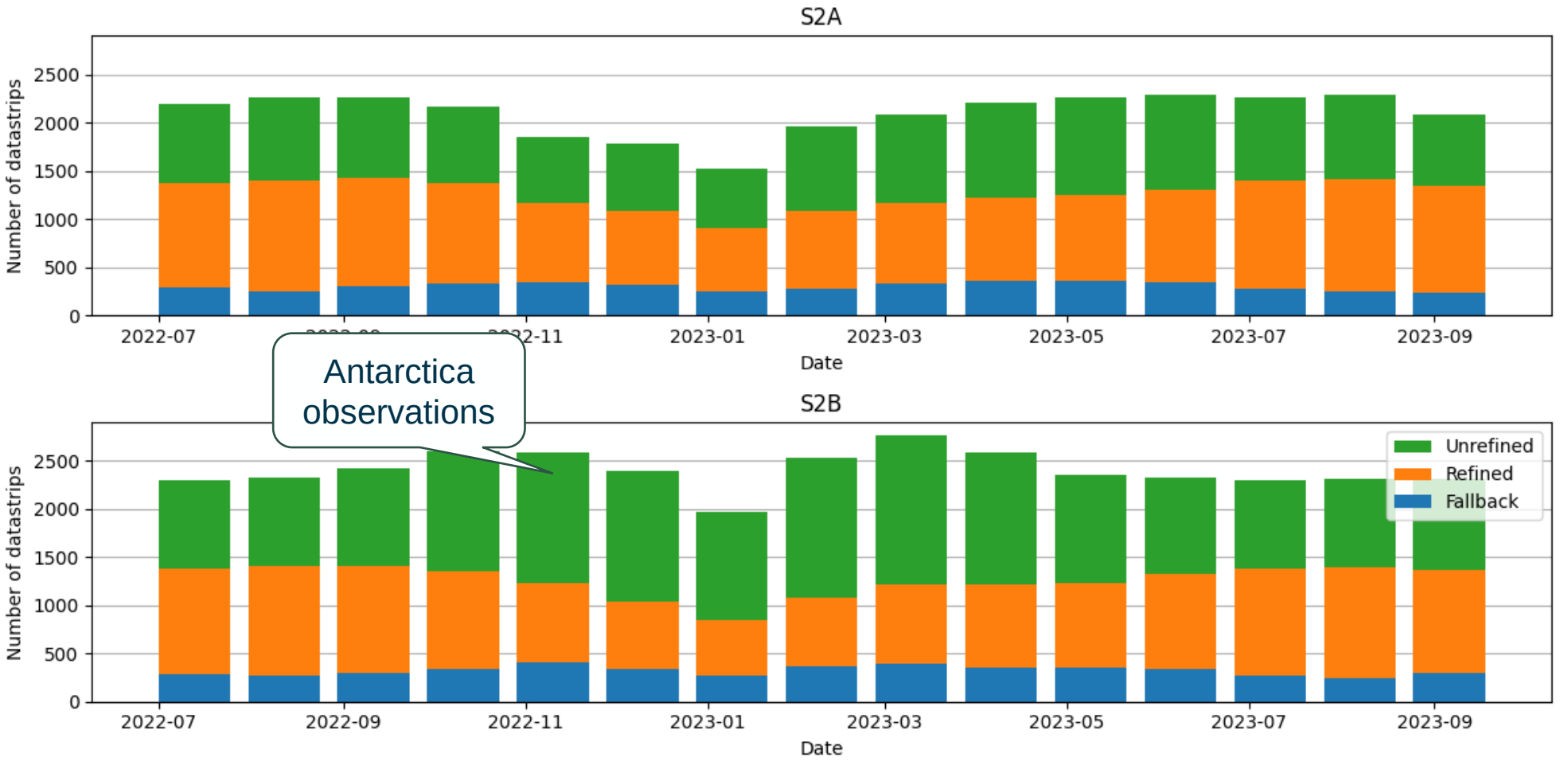
Mean ACT error (m)	7.75m
Mean ALT error (m)	6.96m
Mean circular error (m)	11.54m



Mean ACT error (m)	6.77m
Mean ALT error (m)	9.40m
Mean circular error (m)	12.50m

Statistics of unrefined products

Fall-back rate ~ 15%



Digital Elevation Model for Ortho-rectification

Since March 2021, the Sentinel-2 L1C processing uses the Copernicus DEM sampled at 90 m

However Collection-1 reprocessing uses the Copernicus DEM sampled at 30 m

improved inter-orbit co-registration in mountainous region

Digital Elevation Model for Ortho-rectification

Since March 2021, the Sentinel-2 L1C processing uses the Copernicus DEM sampled at 90 m

However Collection-1 reprocessing uses the Copernicus DEM sampled at 30 m

improved inter-orbit co-registration in mountainous region

Multi-spectral co-registration

Multi-spectral co-registration assessed through dense matching on flat areas

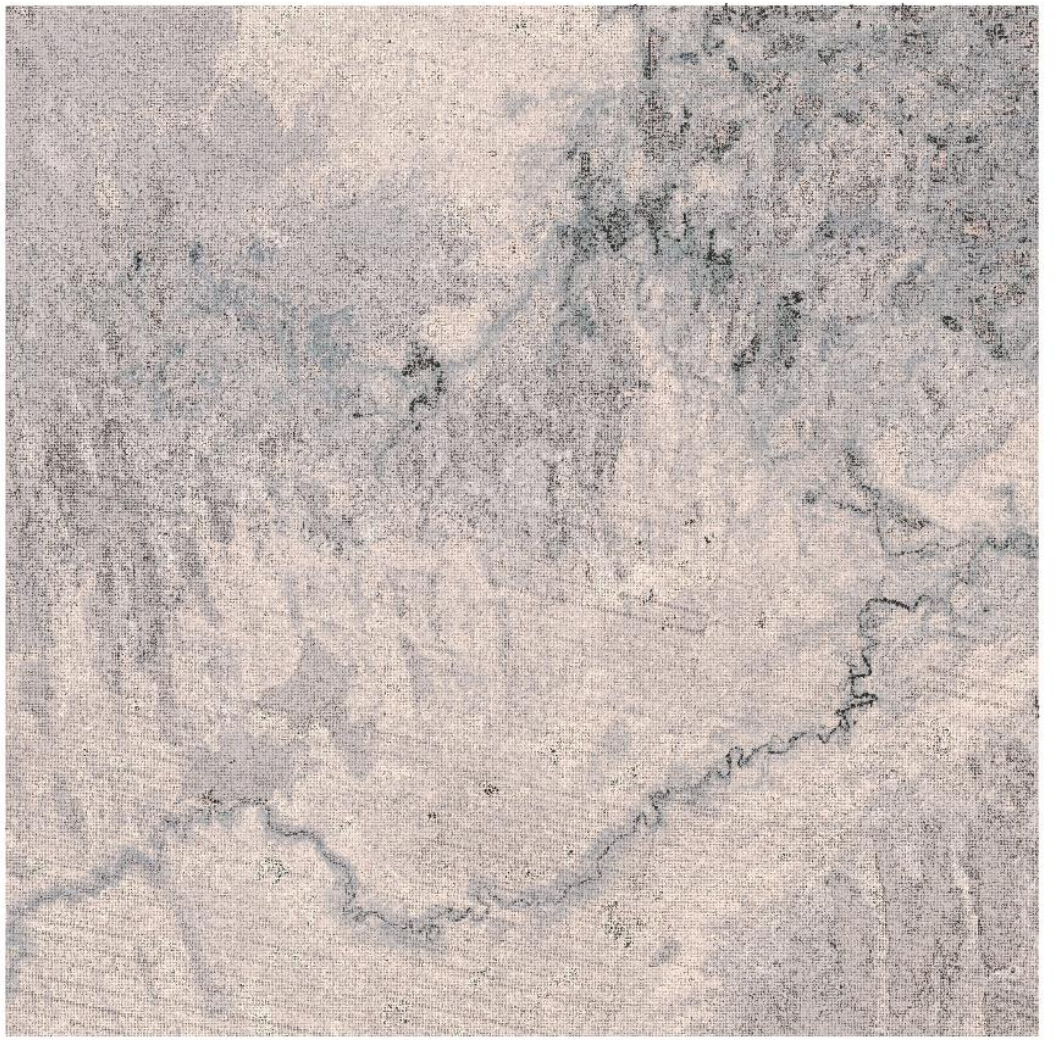
Strict filtering of cloud is critical

Displacement maps show impact of

- high-frequency oscillations of the line-of-sight
- localized error due to resampling
- potential alignment biases

Performance requirement at 3 s (99.7%) but robust measurements are difficult

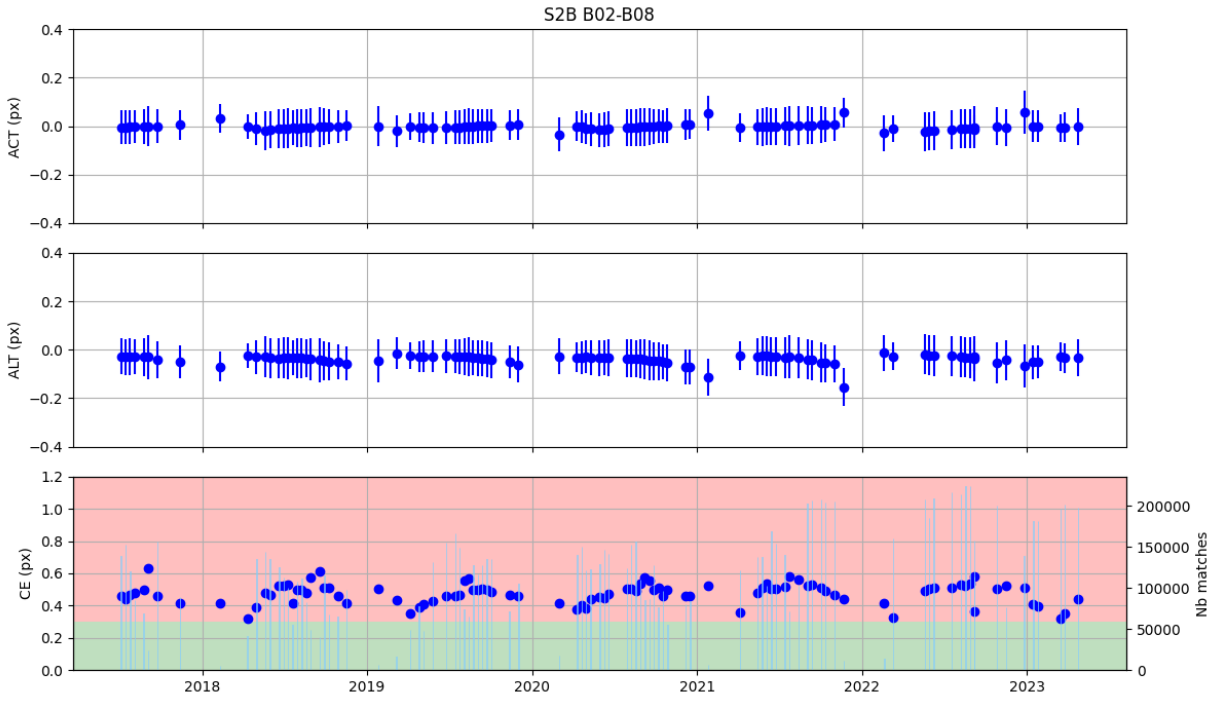
For 60 m bands B09, B01, co-registration measured with a spectrally close band (B08 and B02) after down-sampling



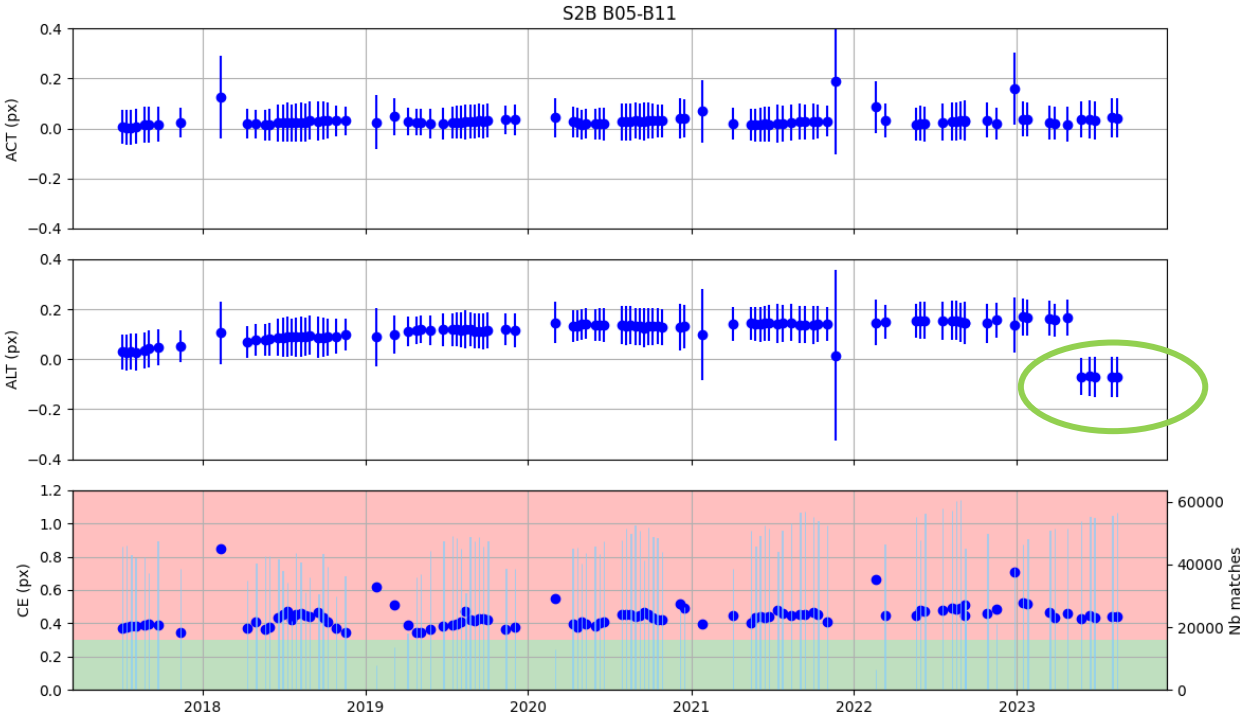
Multi-spectral co-registration

Performance generally in line or close to specifications

10 m bands: worst case B02/B08
Dispersion but no bias



20 m bands: evidence of ALT bias B05/B11
Recalibrated in spring 2023



Conclusion and perspectives

Refinement performance is generally good but with room for improvement

- align performance of S2A on S2B (in progress)
- use of database of GCP instead of full GRI images: more robust and efficient processing, possibility of a-posteriori performance assessment

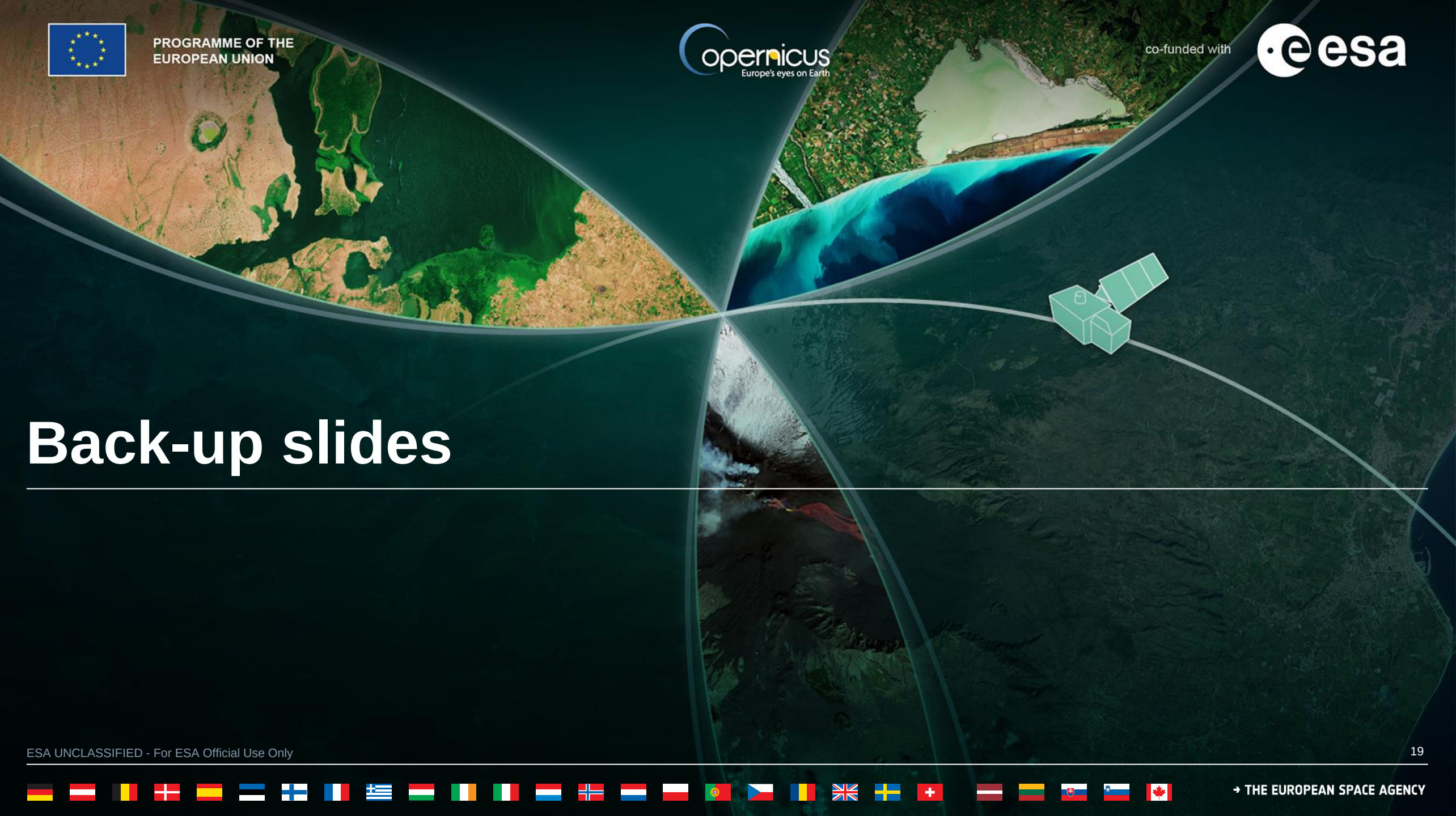
Complete time series of refined products thanks to Collection 1 reprocessing

Further improvement of near time production thanks to 30 m DEM in the near future

S2B spectral co-registration improved by recent re-calibration

Funded by the EU and ESA

European Union



Back-up slides

Map of GRI tiles used for validation

Number of matches linked to cloud-free revisit time