



SENTINEL 2

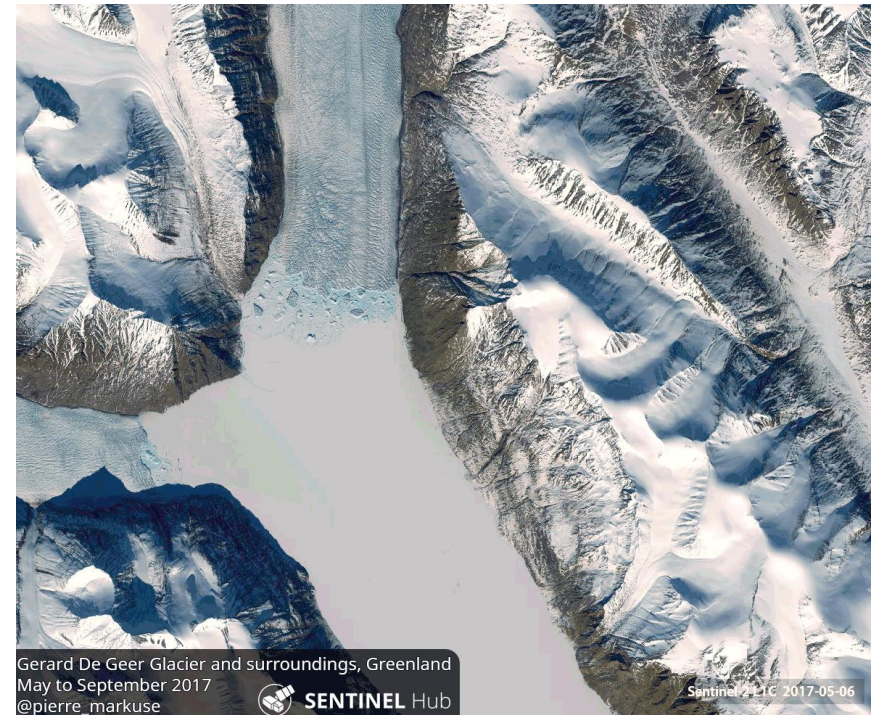
Mission Performance Centre



SENTINEL 2 GEOMETRIC CALVAL

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- ➔ Geometric accuracy is critical to analyse time series at medium resolution
 - › Contribution of geolocation error to radiometric uncertainty
 - › Sentinel-2 requirement: multi-temporal registration better than 0.3 pixel
- ➔ Relative registration is what matters most to users
 - › But cannot be reached without a good absolute geolocation (and a good DEM) in mountainous areas
- ➔ Geometric accuracy contributes also to image quality (spectral co-registration)



→ Copernicus Mission requirements

- › Without GCP (current processing baseline)
 - Absolute: CE 95 < 20 m at Level 1B (sensor geometry)
 - Multi-temporal: no requirement
- › With GCP
 - Absolute: CE95 < 12.5 m at Level 1C

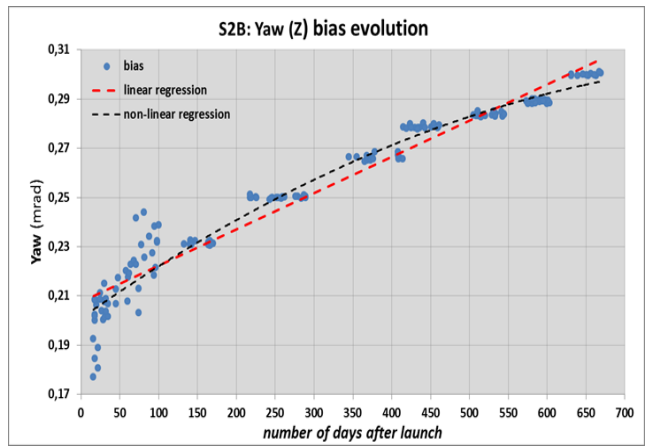
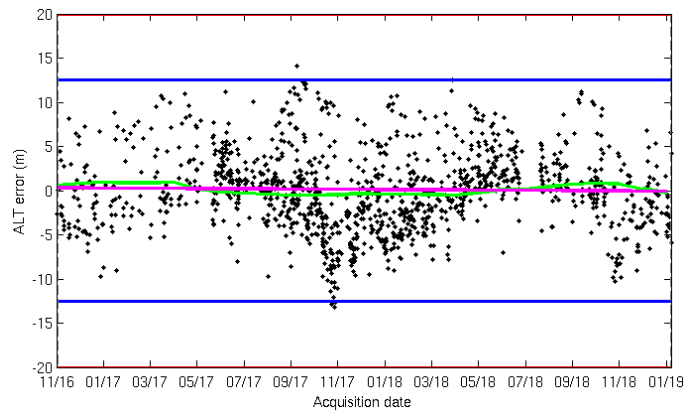
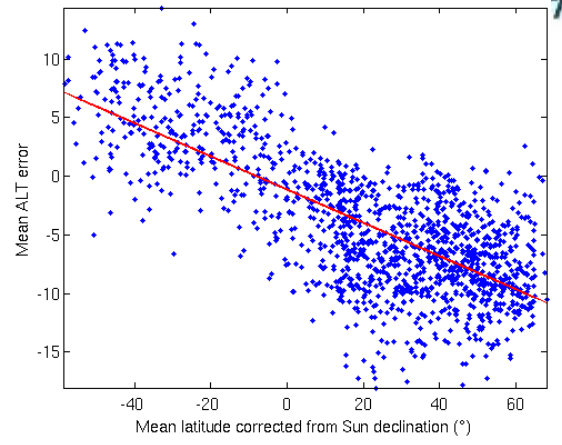
→ MPC Performance Targets

- › Without GCP: current targets
 - Absolute CE 95 < 12.5 m at Level 1C, < 10 m for Europe
 - Multi-temporal (any pair of products): CE95 < 15 m
- › With GCP, to be confirmed
 - Absolute < 10 m globally
 - Multi-temporal, same satellite, same repeat orbit: CE95 < 3 m
 - Multi-temporal (any pair): CE95 < 5 m

- ➔ How to ensure a good geometric performance ?
- ➔ Sentinel-2 satellite design
 - › High-end AOCS sensors
 - › High-stability instrument, and Star Tracker connected to optical bench
- ➔ However this is not enough to achieve geometric accuracy requirements
 - › Temporal drift of alignments at different time-scales
 - › Other sources of errors (star catalogue errors, attitude determination filter convergence...)

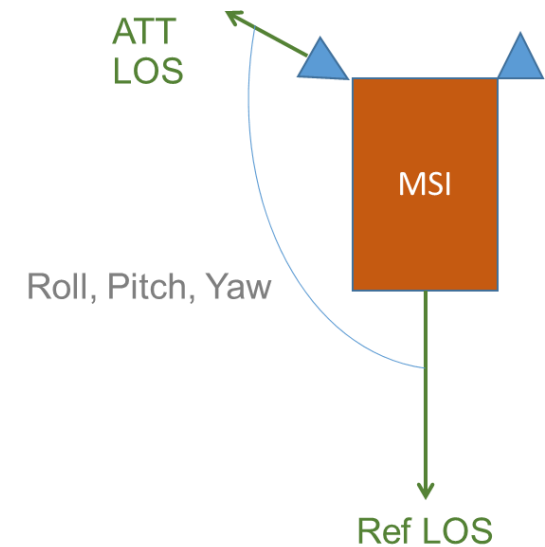


- ➔ Temporal drift of biases at different time scales
- ➔ Orbital
 - › Mostly along-track
 - › S2B: 20 m peak to peak, slightly lower for S2A
- ➔ Seasonal
 - › Mostly along-track
 - › A few meters
- ➔ Post-Launch and long term
 - › All axes
 - › S2A stabilized after one year
 - › S2B still evolving after more than 2 years
- ➔ Short-term oscillations (2 mHz)
 - › Variable amplitude, 4 m worst-case



→ Spacecraft geometric model

- › Estimation and correction of Roll, Pitch, Yaw alignment angles
 - Adjusted as required to optimize absolute accuracy
- › Time-lag between reference and sensing time
 - Characterized during commissioning phase

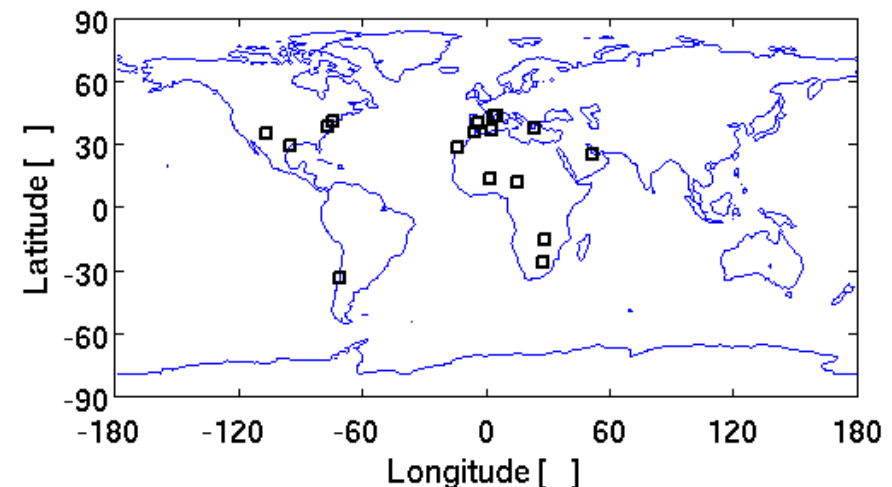


→ How?

- › Adjustment versus as set of reference scenes equipped with GCPs

→ Responsible

- › MPC/Airbus

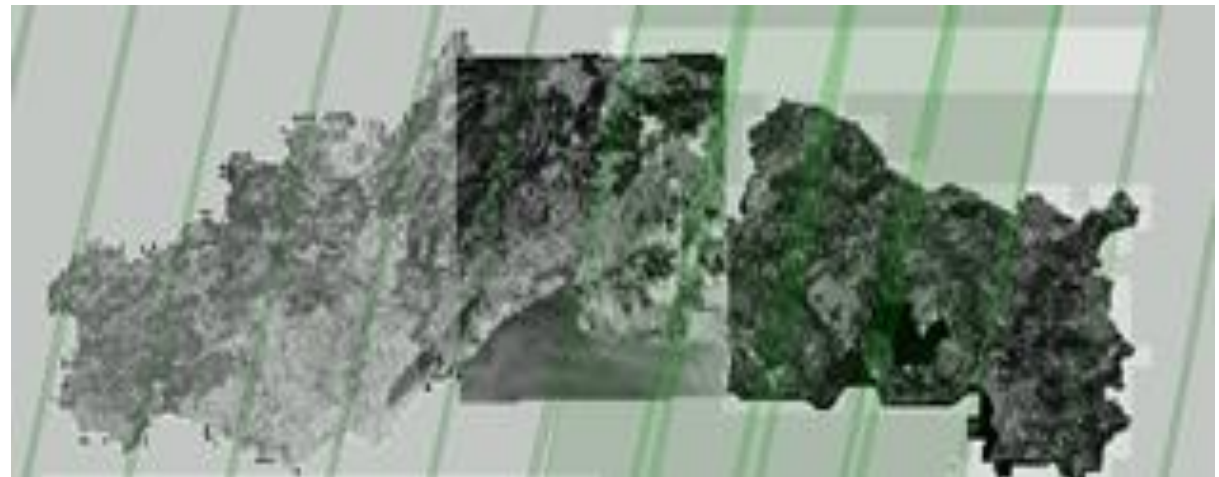
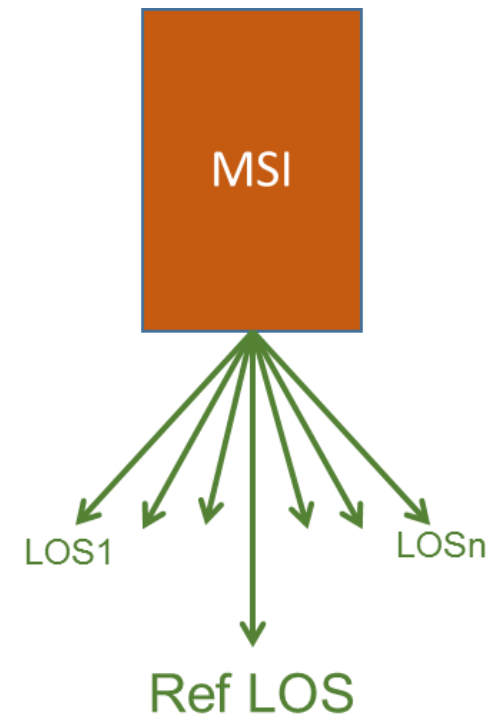


→ Relative line of sight calibration

- › Relative line-of-sights for each pixel of each spectral band
 - Characterized during commissioning phase

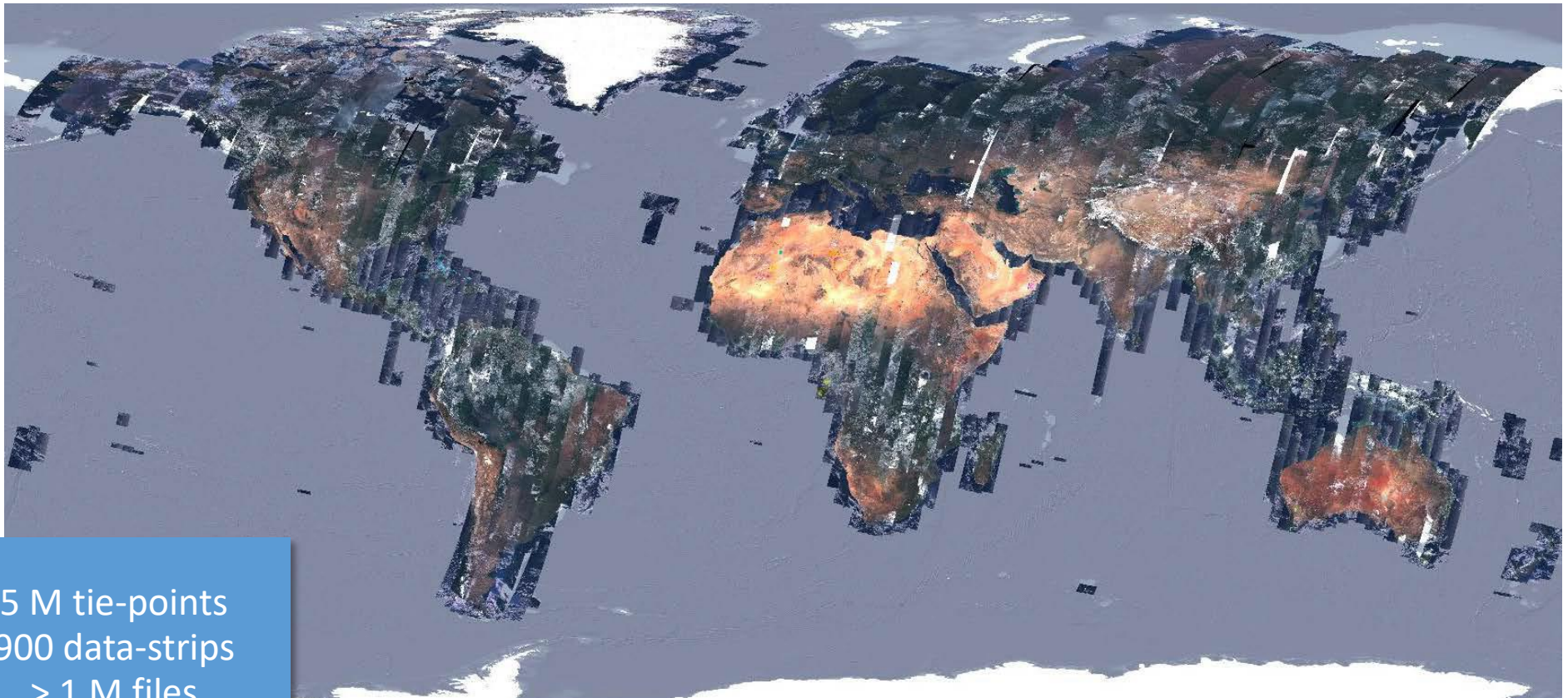
→ How?

- › Acquisition on a large site covering the full swath equipped with GCPs



➔ The Global Reference Image (GRI)

- › A set of Sentinel-2 data-strips covering the globe
- › Geometry improved by global spatio-triangulation by MPC/IGN



5 M tie-points
900 data-strips
> 1 M files
> 3 TB of data

➔ The Global Reference Image (GRI)

- › Validation data from CNES: geometric error against independent GCPs

Area	Mean Error	95%
Europe	5.2 m	6.4 m
Asia	5.3 m	7.0 m
Australia	4.8 m	6.8 m
Africa	5.0 m	7.1 m
South America	5.3 m	6.5 m
North America	5.3 m	7.3 m
Isolated islands	N/A	N/A

→ Geometric Refinement

- › Look for matching image features between current datastrip and GRI
- › Adjust viewing model parameters to minimize geometric error

Current Product: 0.52 pixel



Refined Product: < 0.12 pixel



➔ Absolute geolocation performance

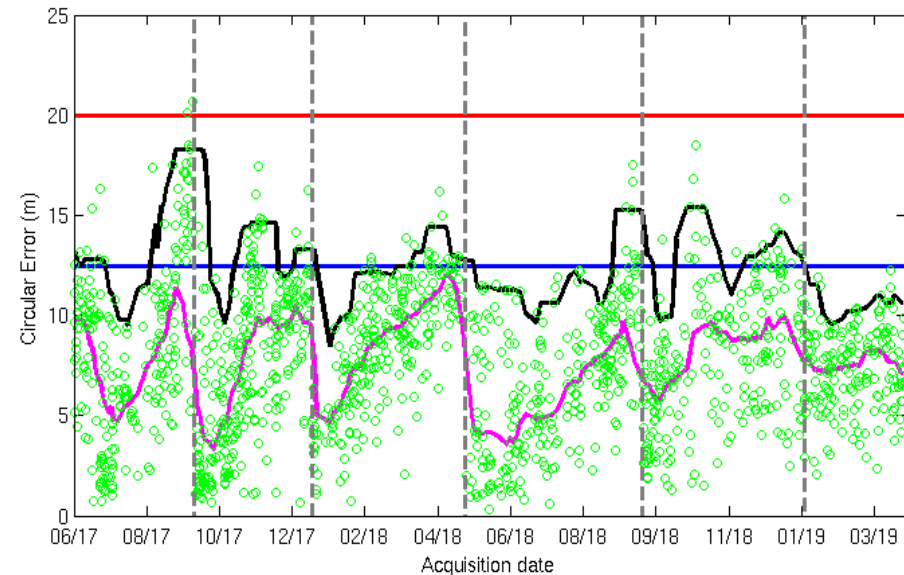
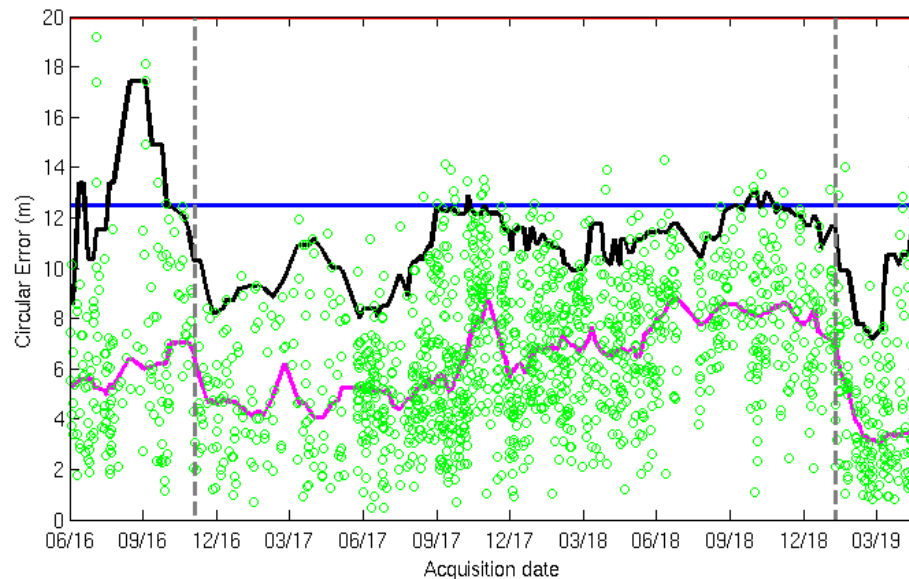
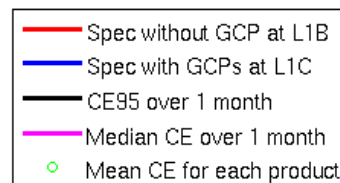
- › Continuously monitored independently by CNES and MPC/ThalesAleniaSpace
- › Using a set of (independent) Ground Control Points
- › Performance assessment: 95 percentile of Circular Error over 1 month

S2A

Circular error @ 2σ : 11.6 m

S2B

Circular error @ 2σ : 13.5 m

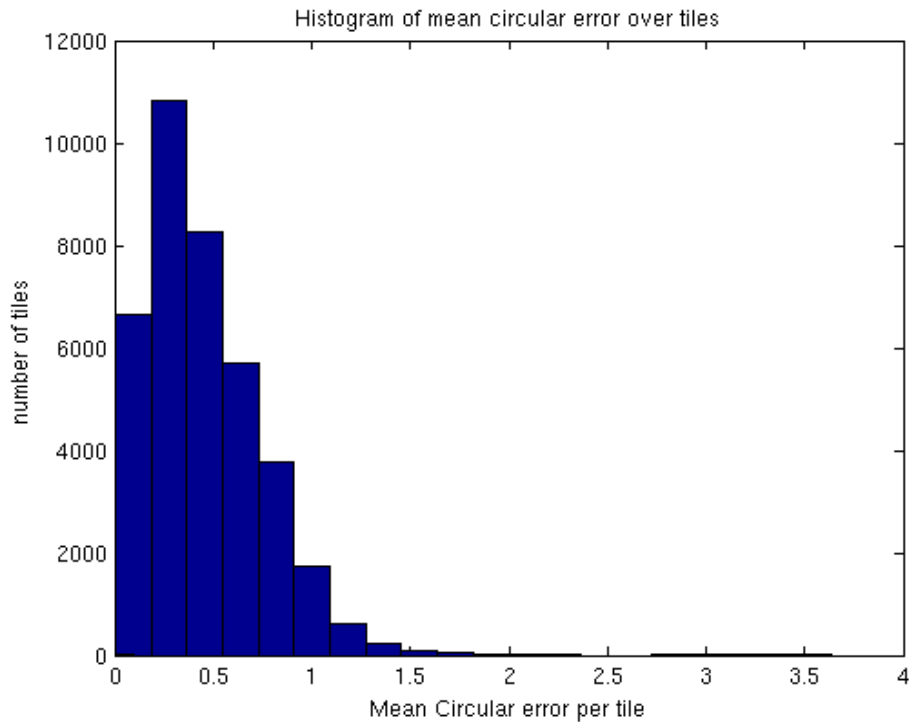


--- Calibrations

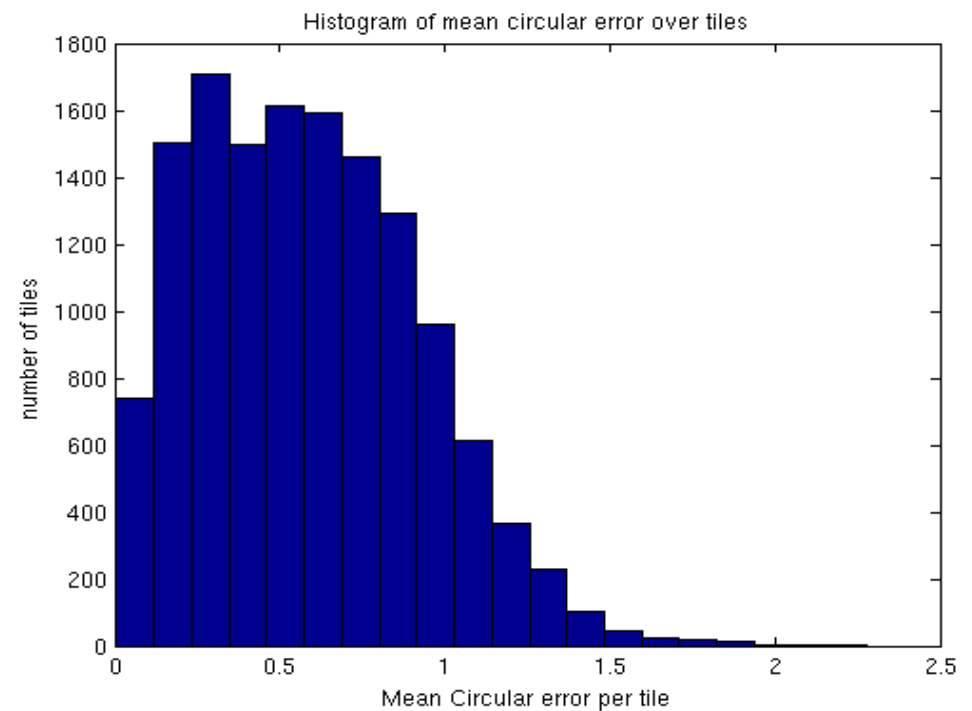
→ Long-term monitoring by MPC/ThalesAleniaSpace

- › Multi-temporal performance, histogram for the complete time series over selected sites

S2A

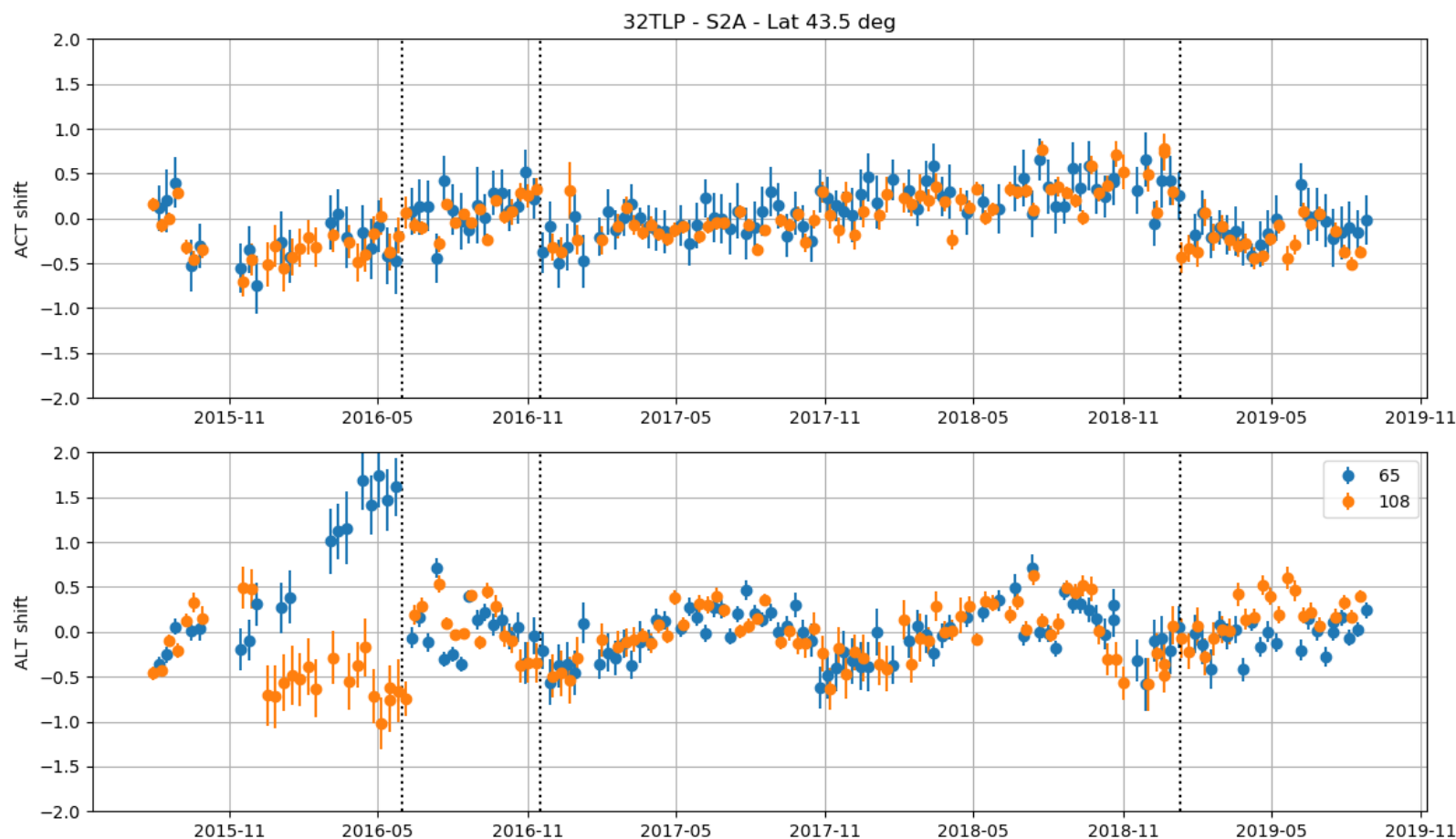


S2B



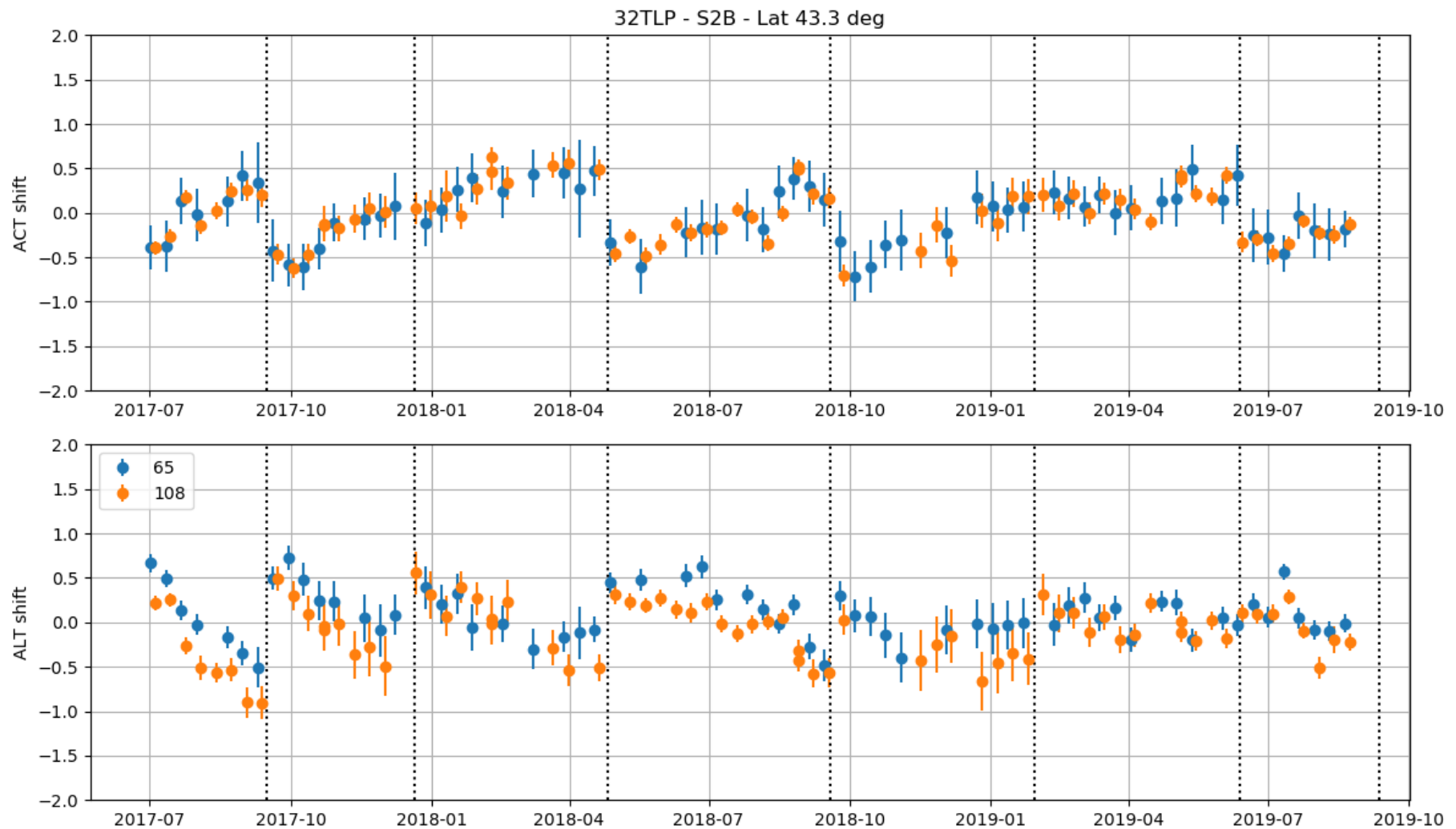
➔ Multi-temporal time series for a given site: S2A

- › Significant improvement of ALT error after 06/2016 (yaw correction)
- › Seasonal oscillations ALT
- › Slow drift ACT, corrected by geometric calibrations



➔ Multi-temporal time series for a given site: S2B

- › Drift of ALT and ACT components, corrected by geometric calibrations



➔ Current Sentinel-2 geometric performance

- › Absolute accuracy maintained within tight bounds thanks to regular geometric calibration
- › However multi-temporal performance is limited by
 - Dispersion of attitude and position measurement error
 - Evolution of alignment angles between two calibrations
 - DEM inaccuracies

➔ Future improvements

- › Geometric refinement: end-to-end validation in progress
- › New DEM with improved accuracy

➔ Outlook

- › The Sentinel-2 GRI could become a reference data set for geometric calibration for other missions