ESA IGS Analysis Centre Status Update

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Introduction

The IGS Analysis Centre (AC) operated by the Navigation Support Office of the European Space Agency (ESA) is located at the European Space Operations Centre (ESOC) in Darmstadt, Germany.

Since joining the IGS in 1992, the ESA IGS AC has played a key role in the Navigation Support Office activities at ESOC.

In 2025, the ESA IGS AC adopted a new processing system, significantly improving computational robustness, efficiency and product quality. This represents a major advancement for the ESA IGS AC.

This poster provides an overview of key initiatives and contributions of the ESA IGS AC. Those include the routine generation of high-precision GNSS products for multi-constellations as well as the provision of GNSS ground station data. In future, the ESA IGS AC aims at including LEO satellites and the Genesis satellite into their routine processing for IGS, benefiting from the additional information and therewith further strengthening its global solution.

Consolidated High Accuracy Multi-GNSS Processing - New Features

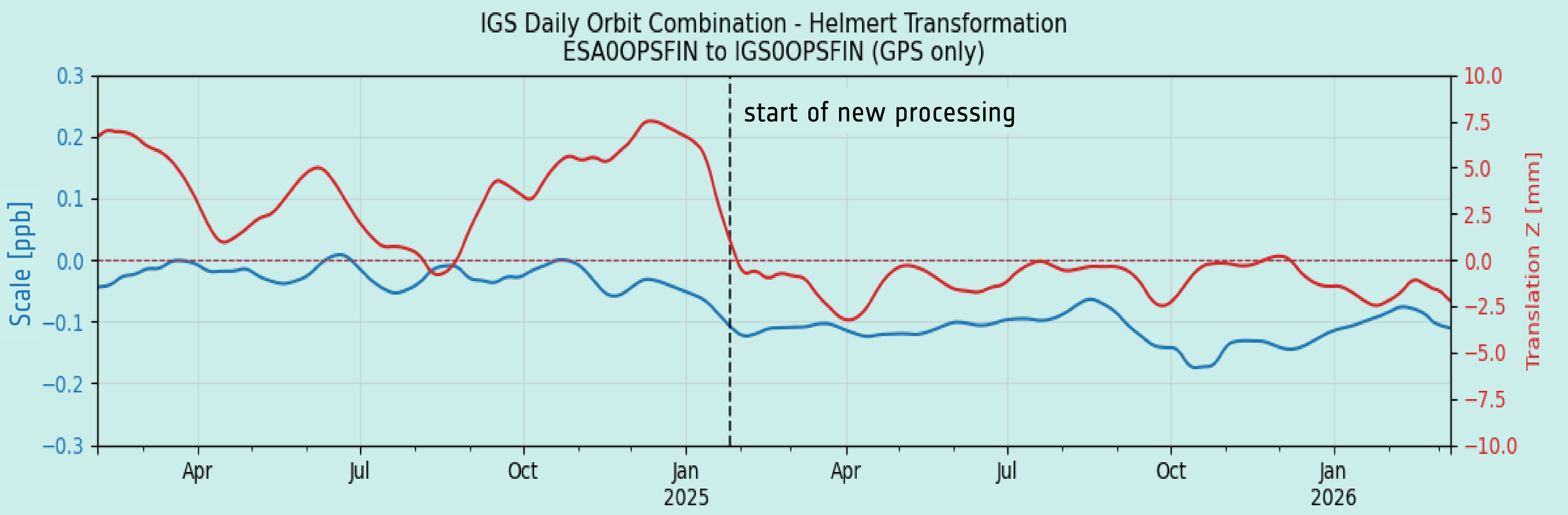
	2024	2025
Software	NAPEOS	EPNS
Processing Style	Single-Batch	Constellation-wise + NEQ stacking
Constellations and Frequency Combinations	GPS (L1W-L2W) Galileo (E1C-E5Q) GLONASS (L1P-L2P)	GPS (L1W-L2W) Galileo (E1C-E5Q) GLONASS (L1P-L2P) BeiDou-3 (L1P-L5P) QZSS (L1L-L5Q)
SRP Box-Wing models	2024 version	2025 version
Number of used stations	150	200
Ground antenna calibration required for used signals	No	Yes
Transmitter Antenna Calibrations	igs20.atx	esa23.atx
Zero-mean P1C1 correction based on	CODE.BIA	ESA0OPSFIN_DCB.BIA
UTC clock alignment	No	Yes: UTC(ESOC)

- Constellation-wise processing simplifies detection of anomalies specific to each constellation.
- Improved data screening through advanced logic, avoiding unnecessary rejections.
- Constellation-wise processing reduces the size of the normal equations, enables parallelisation, and significantly lowers RAM usage and processing time.
- Only calibrated ground stations are used, bringing single-constellation solutions closer together and simplifying ITRF alignment of the multi-constellation product.
- Independence is increased by using in-house bias estimates for P1C1 correction.
- All products are aligned to UTC via the UTC(ESA) timing facility.

Orbit Products Improvement

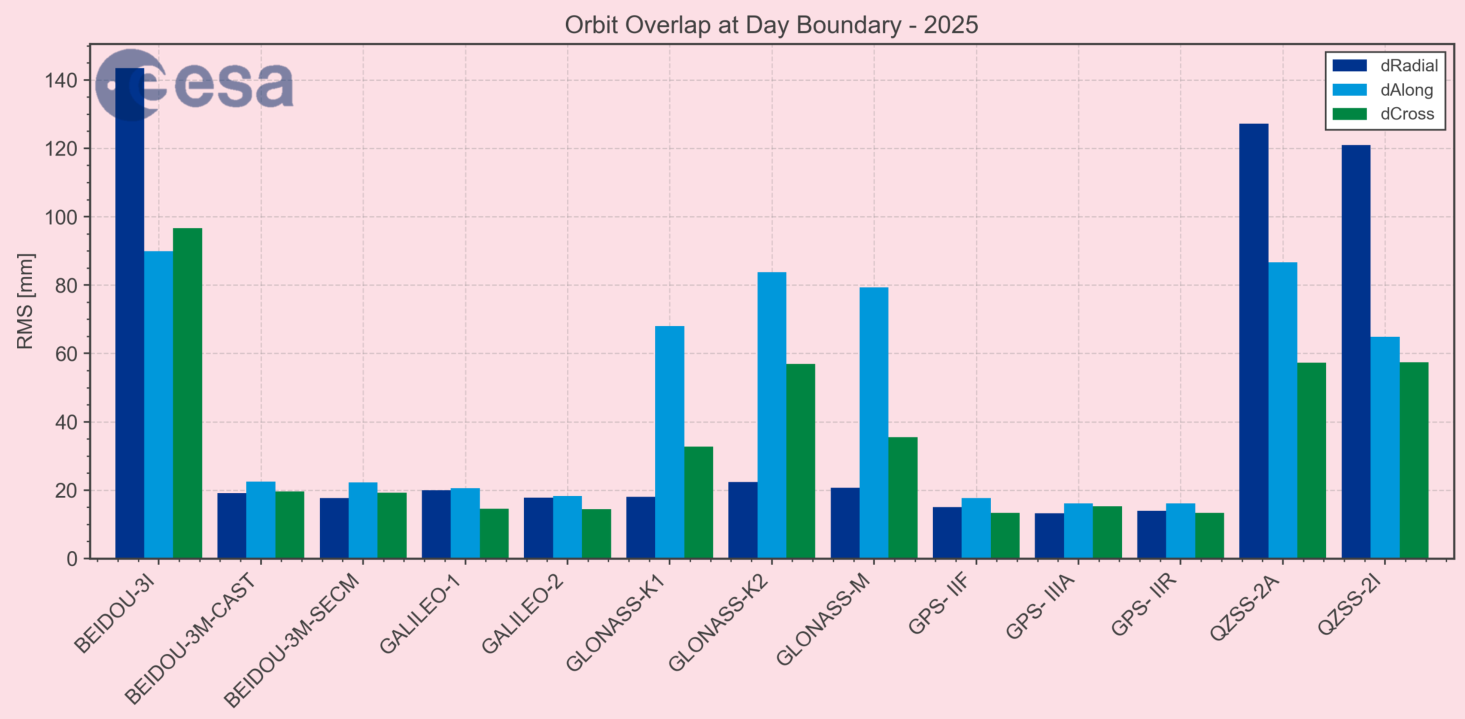
The precise estimation of the GNSS orbits is at the core of the development efforts at the ESA IGS AC. The transition to the new processing system came with a noticeable impact, which is visible when comparing against the IGS combined solution (Helmert Transformation): ESA IGS AC now uses the esa23.atx file, which applies several manufacturer-provided phase centre calibration values. The corresponding values in igs20.atx, used by most IGS ACs, are largely based on the same calibrations but have been rescaled. The orbit scale offset (see Figure) increased from -0.03 to -0.11 ppb.

Enhanced GPS and Galileo Box-Wing models result in a smaller mean offset and reduced standard deviation for the Z-Translation of the Helmert Transformation: The mean offset decreased from 3.9 to -1.11 mm and the standard deviation decreased from 2.31 to 0.85 mm.



Internal Orbit Consistency

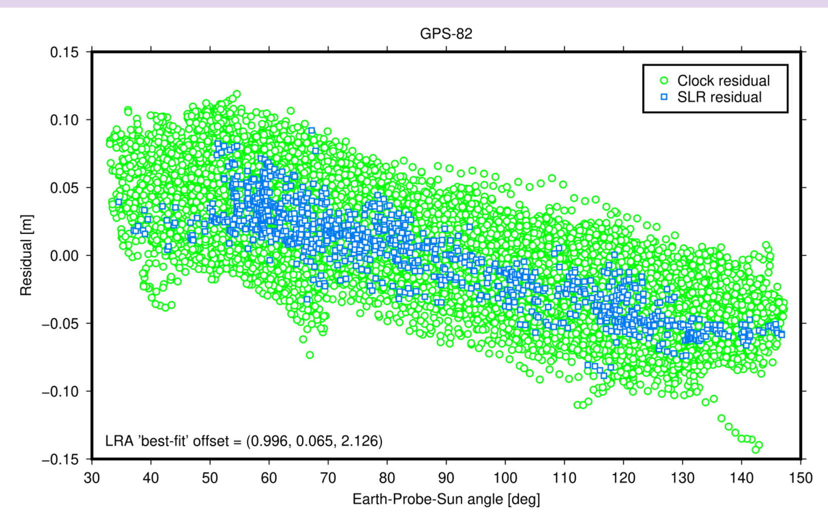
The default estimation approach of the ESA IGS AC is based on daily runs with 24h intervals at 300s observation sampling rate. Each day is estimated independently. While being very efficient and transparent, this approach leads to orbit and clock discontinuities at the day boundaries (midnight-epoch). The orbital overlap offset is used as an internal quality measure, and optimization efforts are aimed towards the minimisation of this offset. In 2025 the orbital overlap offset of Galileo-2 (FOC) dropped below 3cm.



SLR Validation for Solar Radiation Pressure Models

ESA greatly values SLR observations of GNSS satellites, making extensive use of this data for refining Solar Radiation Pressure (SRP) models and for validating both orbit and clock products. The SRP models are calibrated to reduce the mean and standard deviation of SLR residuals over extended timeframes, especially during eclipse periods.

After more than three decades, two GPS satellites (SVN082 and SVN083) have again been equipped with retroreflectors. A first analysis of the SLR residuals for SVN082 indicates radial orbit errors at the level of approximately +/-0.1 m, which are directly reflected in the satellite clock estimates. The characteristic error signature observed for SVN082 is present in the orbit and the clock submissions from all IGS ACs.

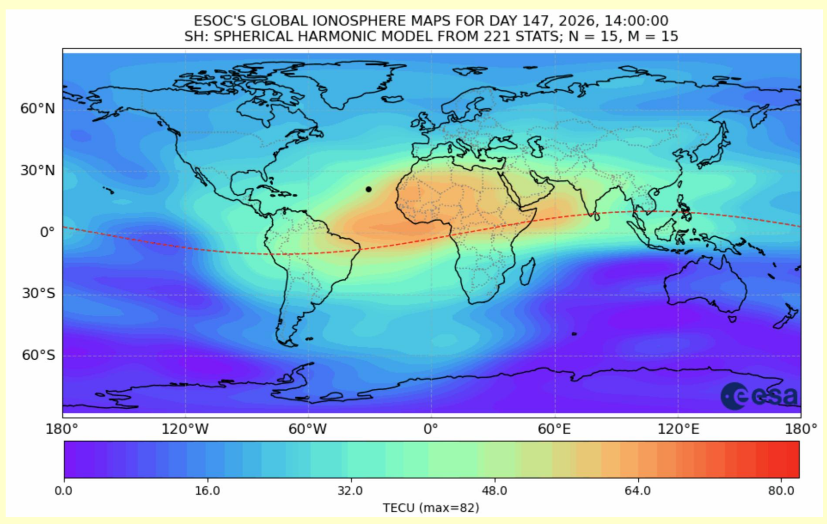


Multi-Constellation Processing (QZSS L1-L5)

By including BeiDou and QZSS in its IGS FINAL contribution, the ESA IGS AC has demonstrated its capability to process multi-constellation solutions. In 2025, the ESA IGS AC transitioned to L1C and L5Q for the QZSS linear combination used in Final products, which is compatible with Galileo E1C-E5a and BeiDou B1C-B2a signals. QZSS Precise Orbit Determination is performed jointly with a GNSS, formerly GPS, now BeiDou. This transition resulted in a decrease of average phase residuals from approximately 1m to 0.75m, and pseudorange residuals from around 10m to 9m for QZSS satellites in geosynchronous orbit, while maintaining orbit quality, because observation geometry continues to be the primary constraint for quasi-zenith satellite orbits. This transition was enabled by the detailed satellite meta information published by the Japanese Cabinet Office.

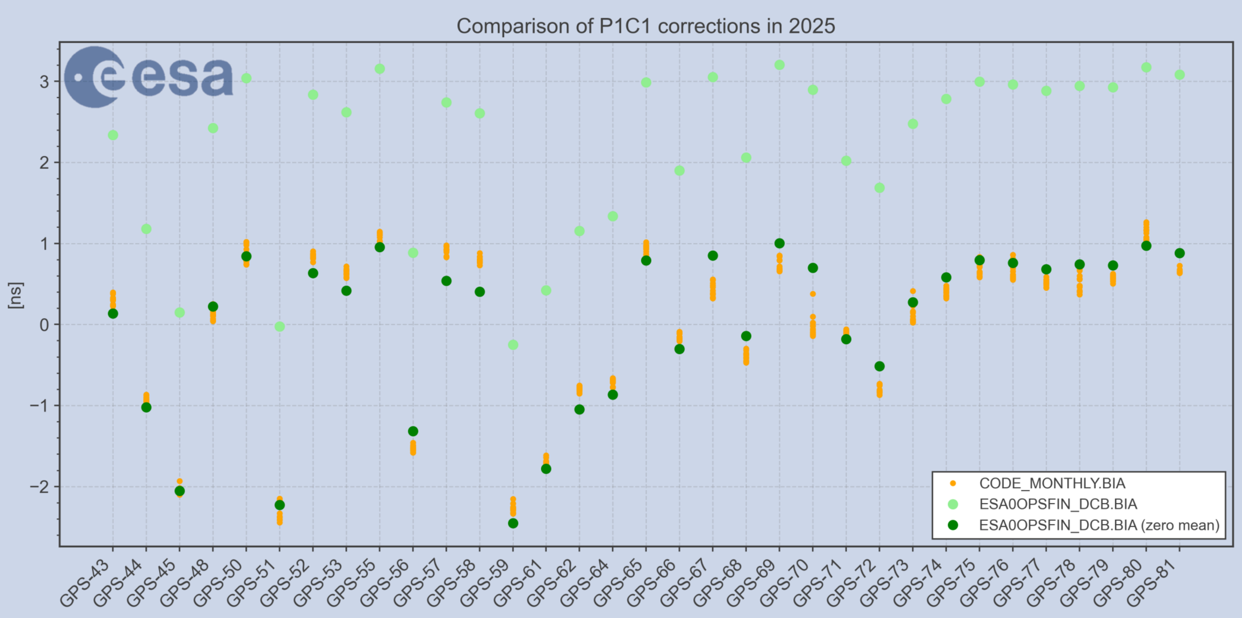
Precise Ionospheric Products

As part of its GNSS product contribution to the IGS community, the ESA IGS AC provides Global Ionosphere Maps in IONEX format. Final maps are available within 4 days with 2h step-size and Rapid maps within 10h with 1 or 2 hours step-size. The maps include GPS, GLONASS, Galileo, BeiDou, QZSS (final only). The example TEC map shows the sub-solar point and geomagnetic equator (dashed line).



Code Biase Reference Frame and P1C1 correction

The ESA IGS AC treats GNSS satellite Differential Code Biases (DCB) as stable over time and has developed a Code Bias reference frame (BREF) with long-term estimates for 19 signal combinations, including C1W-C2W and C1C-C2W. Combining those enables calculation of the C1W-C1C (P1C1 correction). In 2025 the ESA IGS AC started using the BREF P1C1 correction to process C1W and C1C together. A daily zero-mean adjustment is implemented across all GPS satellites, where the standard deviation remains unchanged.

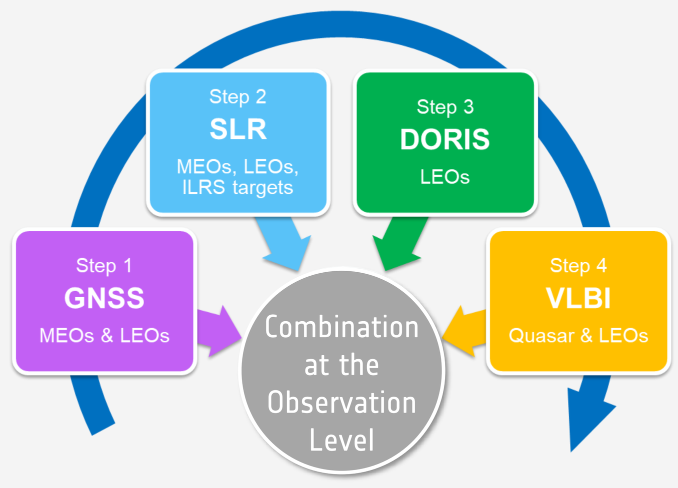


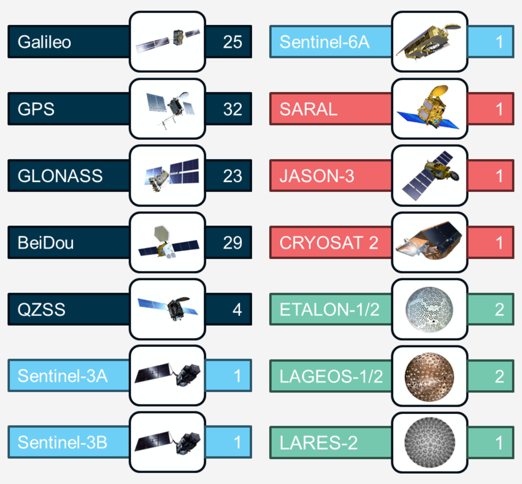
Combination at the Observation Level – LEOs and Genesis Mission

ESA currently investigates and develops in a step-wise approach the combination of all four geodetic techniques (GNSS, SLR, DORIS, VLBI) at the observation level. This includes observations from LEO satellites and the future ESA Genesis mission. The benefit of this approach stems from the complementary strengths and weaknesses of the four space-geodetic techniques in recovering geodetic parameters. Systematic inaccuracies in each technique can be detected and mitigated more effectively at observation level. The methodology allows to

- Improve internal consistency of Galileo and GPS orbits,
- Maintain or improve EOP agreement with respect to IERS EOP20C04,
- Improve Geocentre consistency to ITRF with reduced uncertainty,
- Maintain terrestrial scale difference stable with respect to ITRF coordinates across solutions.

For the future, ESA aims at including LEO satellites and the Genesis satellite into their routine processing for IGS, benefiting from the additional information and therewith further strengthening its global solution.





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