Integer ambiguity resolved orbits and the benefits of combined Sentinel and GPS processing

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Introduction

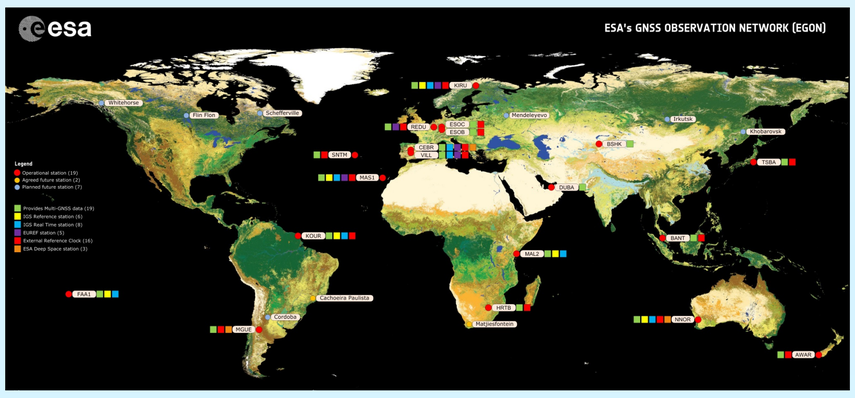
The Navigation Support Office at ESA/ESOC provides GPS and Sentinel high accuracy state of the art orbits and clocks in the context of the Copernicus activities. An overview of our current processing is presented. We then show the benefits of a combined processing of two Sentinels in a global network approach together with the GPS satellites and station network against the standard global network approach without any LEOs. We then compare the Sentinels integer resolved ambiguity orbits based on a global network approach and based on the GFZ method[1].

GPS POD

GPS orbits and clocks are estimated using our in-house developed software package NAPEOS[2], following an IGS alike processing taking as input observations from a station network of 100 IGS and EGON stations. The products are provided with various latencies: NRT with an average latency of 25 minutes, Rapid with a latency of 12 hours and Final with a latency of 4 days.

Processing advancements

The processing runs operationally 24/7 with a high level of redundancy, based on our stations network *ESA's GNSS Observation Network* (EGON).

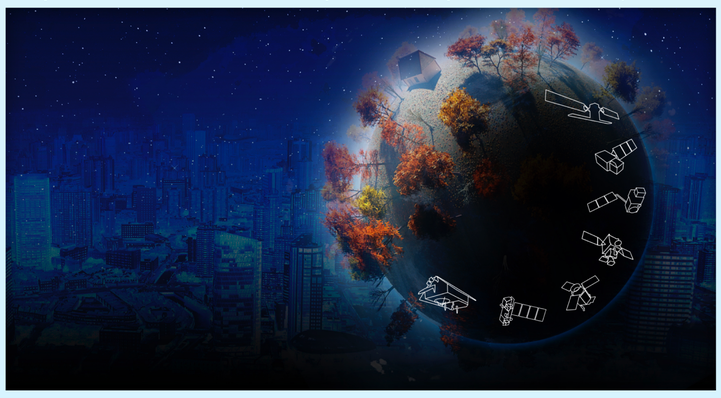


Sentinel POD

All current 6 Sentinel satellites are equipped with GPS tracking receivers and the next generation will be equipped with multi-GNSS receivers. In ESA/ESOC we convert the GPS Level-0 data (GPS observations tracked by the Sentinels) into RINEX files. These are used as input, along with our high accurate GPS orbits and clocks, to perform the Sentinel POD with NAPEOS. Orbit products are delivered daily with a 24-hour (Rapid) and 7-days (Final) delay. The quality of our products is continuously monitored.

Processing advancements

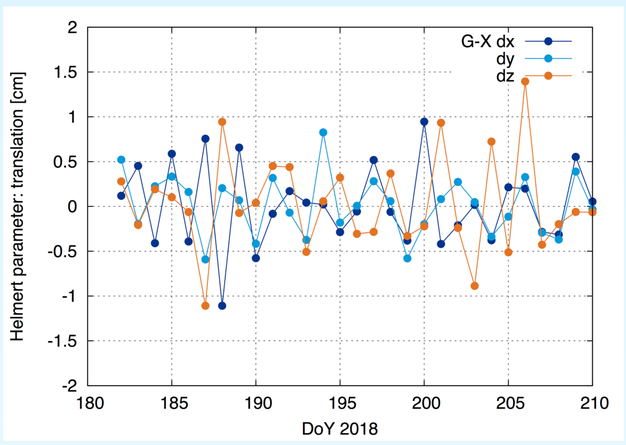
The precise dynamic orbit determination with highly accurate box-wing models for all Sentinels for the aerodynamic and radiation pressure perturbations, runs operationally 24/7.



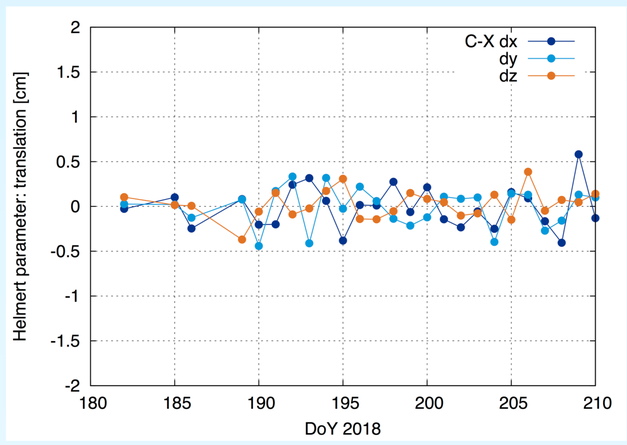
COOL: Combination On the Observation Level

We call *COOL approach* the global solution that combines in a single processing multiple observation types (e.g., GNSS, Doris, SLR) and multiple satellite types (e.g., MEOs, LEOs). Within the scope of this activity we combine in a single process the GPS satellites, a network of 60 GPS stations and 2 LEO satellites, i.e. Sentinel-3A and 3B, carrying GPS receivers. This solution is compared to the typical global solution which involves only GPS satellites and a station network without LEOs. Results and improvements of the COOL approach are shown in this section, in terms of station position repeatability and GPS day-boundary orbit overlaps.

GPS + Network solution

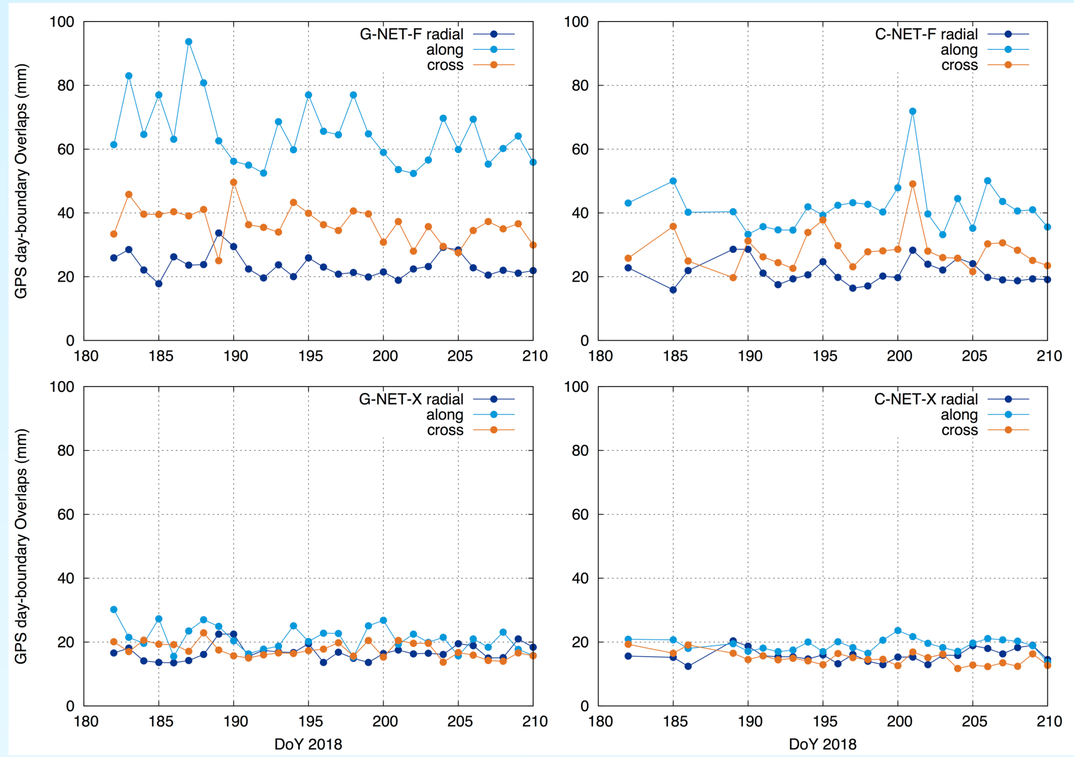


GPS + Network + LEOs solution (COOL)



GPS + Network solution | **GPS + Network + LEOs solution (COOL)**

Float ambiguities



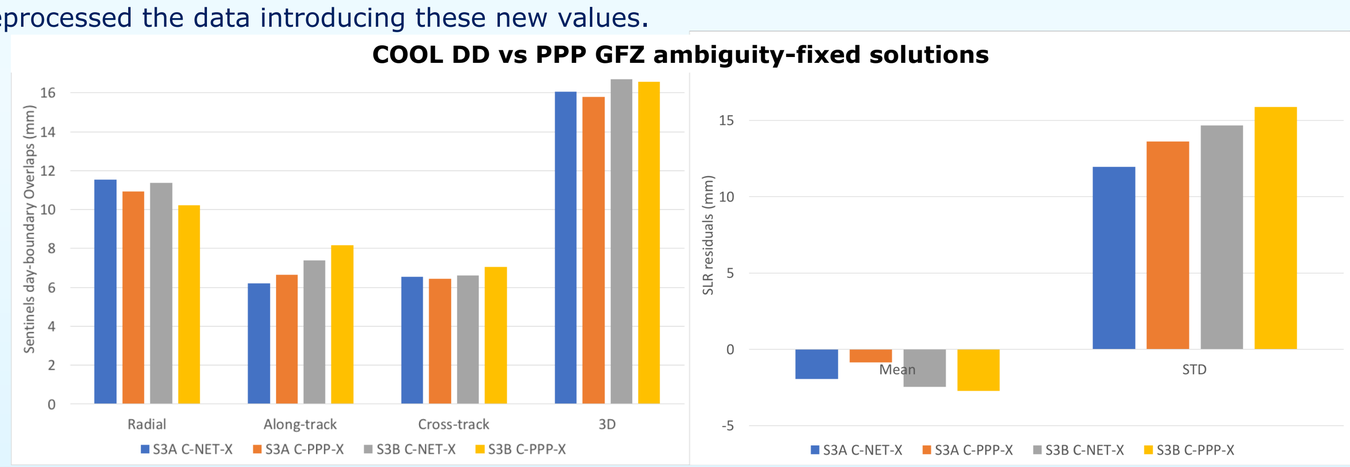
Fixed ambiguities

Sentinel-3 ambiguity fixing

In this section we show the comparison between two methods for resolving the GNSS carrier-phase ambiguities, applied to Sentinel. The first one consists in solving the double-differenced (DD) ambiguities in a global solution (COOL approach) forming DDs with the station-station, station-LEO and LEO-LEO baselines. The second one is the GFZ approach, consisting in estimating the fractional parts of the single-difference (SD) uncalibrated phase delays (UPDs) between satellites from a global network; these UPDs are then applied as corrections to the LEOs, making the SD ambiguities integer, allowing to resolve them in a PPP approach without the need of a station network. DD and GFZ approaches lead to similar results, with orbital differences of about 7 mm in average.

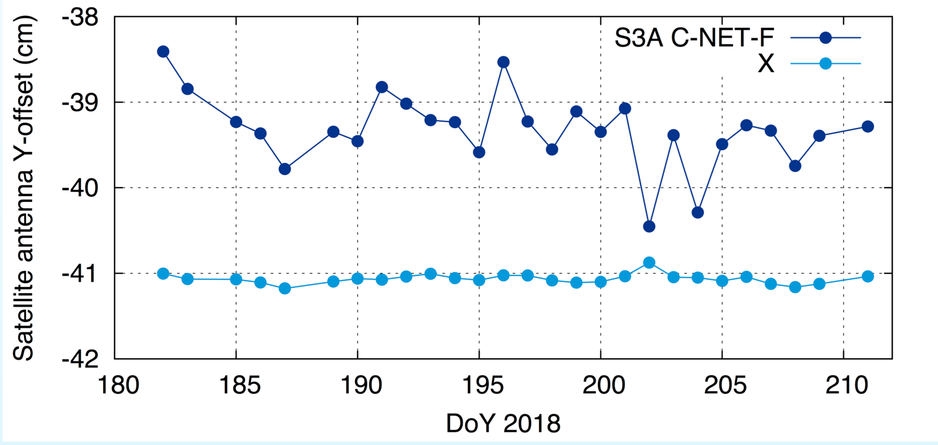
The ambiguity-fixed solutions are more sensitive to the centre of mass (CM) or phase centre offset (PCO) errors compared to the float solution. For this reason we first estimated new Y- and Z-PCOs for Sentinel-3A and 3B, and we reprocessed the data introducing these new values.

COOL DD vs PPP GFZ ambiguity-fixed solutions



New PCO values*	S3A	S3B
X-PCO (m)	1.3910	1.3910
Y-PCO (m)	-0.4107	-0.4107
Z-PCO (m)	-0.8784	-0.8735

* Sentinel-3 body-fixed reference frame



Conclusions

- The Navigation Support Office at ESA/ESOC operationally computes highly accurate orbits and clocks for the GPS and Sentinels constellation.
- Processing together GPS + Station Network + LEOs (COOL) significantly improves the accuracy of the GPS and Sentinel orbits and the network positions repeatability.
- Fixing the Sentinel-3 ambiguities with the GFZ UPDs method leads to orbital solutions very close to the DD global ones, but with less effort due to the PPP approach.

References

1) M. Ge, G. Gendt, M. Rothacher, C. Shi, J. Liu, *Resolution of GPS carrier-phase ambiguities in precise Point Positioning (PPP) with daily observations*, J. Geod. (2008)
2) T. A. Springer, J.M. Dow, *NAPEOS Mathematical Models and Algorithms*, DOPS-SYS-TN-0100-OPS-GN 1.0, 05/09/2009

Points of contact

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