

Copernicus POD Service: Reprocessing of the Sentinel-1, -2, and -3 Orbits

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See also: Peter et al.: Copernicus Sentinel-1 Orbits: Results of an Offline Reprocessing

Fernández et al.: Single-receiver ambiguity resolution for Copernicus Sentinel Satellites at the Copernicus POD Service

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Introduction and motivation

The Copernicus POD (Precise Orbit Determination) Service delivers as part of the PDGS of the Sentinel-1, -2, and -3 missions orbital products and auxiliary data files for their use in the corresponding PDGS processing chains. The most precise results are the NTC (Non-Time Critical) orbit products delivered for the Sentinel-1 and -3 missions. These orbits are part of the final SAR (Synthetic Aperture Radar) products in the case of Sentinel-1 and are serving as backup (for the CNES orbits) for the generation of the final altimeter products in the case of Sentinel-3. Consistent time series of the orbit products are a requirement for highest-level final products of the different satellite missions.

However, due to external developments such as the updates of the ITRF (International Terrestrial Reference Frame) the time series get inconsistent. In addition, necessary model improvements and updates or correction of wrongly used instrument reference points lead to inconsistencies. A rigorous reprocessing is the usual way to provide consistent orbit time series after major switches necessary in the operational processing.

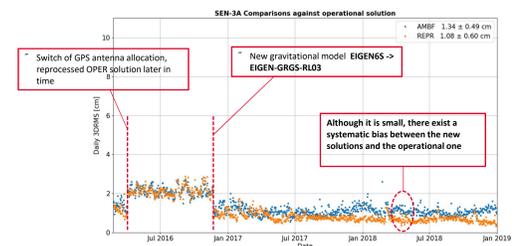
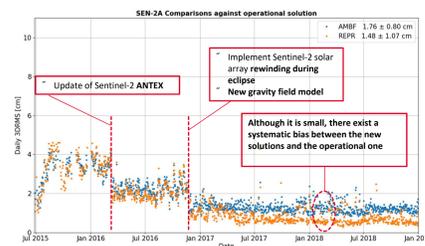
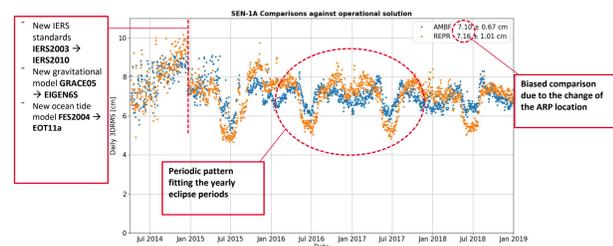
The Copernicus POD Service has done an offline reprocessing to have consistent time series available for all Sentinel satellites. This includes all model updates and improvements made in the processing system since the launch of Sentinel-1A (April 2014). Updates (S-3) and correction of wrongly used antenna reference points (ARP) (S-1) are also included as well as a full reprocessing of the GPS orbits and clocks in the ITRF14/IGS14 reference frame. The reprocessed GPS orbits and clocks have an arc length of 36 h instead of the usual 24 h, because all Sentinel orbit products cover more than 24 h. Thus the common discontinuity of the GPS orbit and clock products at the day boundaries is avoided.

In addition a full reprocessing is performed with single-receiver ambiguity fixing using the CNES/GRGS wide-lane-satellite biases (WSB) together with the corresponding GPS orbits and clocks.

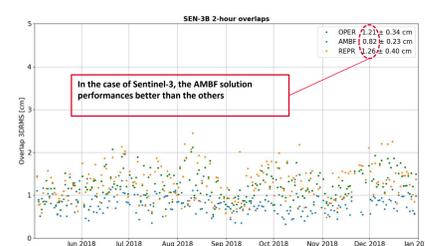
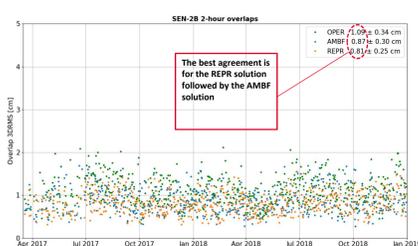
The improvements of the resulting Sentinel orbit time series are discussed and analysed. The final goal is to have the reprocessed orbits included in the official Sentinel processing procedures at the individual PDGS of the missions.

Comparisons to operational solutions

The two reprocessed orbit series **REPR** and **AMBF** are compared to the **OPER** solutions. Many updates and improvement steps are visible in the time series. The comparison for S-1A (and also S-1B) shows large differences due to the usage of the correct GPS ARPs and updated PCO location. Detailed analysis of the S-1 reprocessed time series is available on the poster **Copernicus Sentinel-1 Orbits: Results of an Offline Reprocessing**.



Orbit overlap analysis



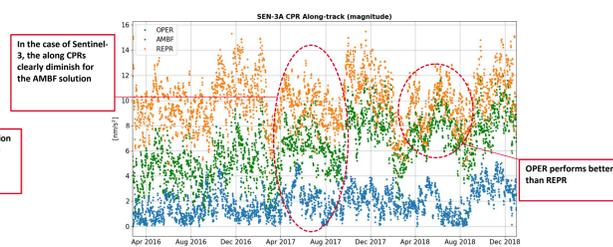
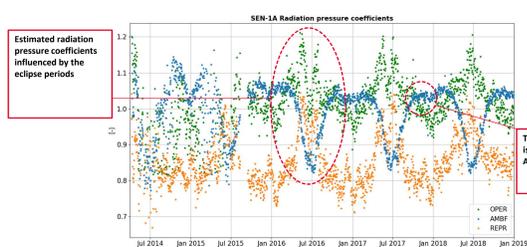
2-h overlaps (23:00 (day-1) – 01:00) are analysed for **REPR**, **AMBF**, and **OPER** solutions. The **AMBF** solution gives smaller overlaps than the **OPER** solution whereas the **REPR** solution show different results. This is not yet fully understood.

An additional **REPR** solution has been generated with exchanged models:

- gravity field model EIGEN.GRGS.RL03 => EIGEN.GRGS.RL04
- atmosphere gravity products from massloading.net => GFZ AOD L1B

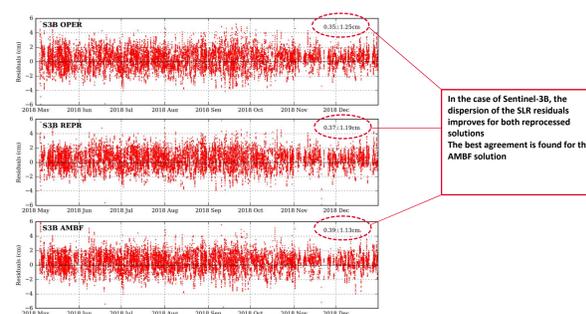
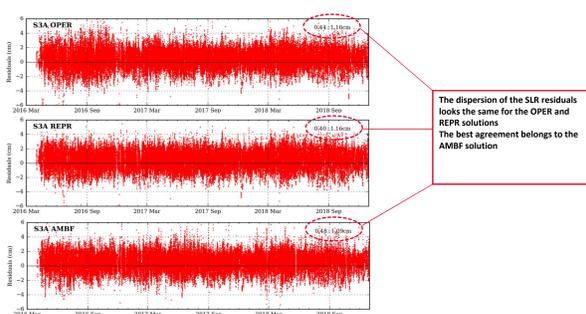
2-h overlaps (cm)	REPR	REPR with updated models
S-1A	0.88 ± 0.40	0.76 ± 0.39
S-1B	0.84 ± 0.32	0.71 ± 0.30
S-2A	0.84 ± 0.27	0.59 ± 0.20
S-2B	0.81 ± 0.25	0.60 ± 0.22
S-3A	1.17 ± 0.42	0.84 ± 0.32
S-3B	1.26 ± 0.40	0.92 ± 0.30

Estimated orbit parameters



Estimated orbit parameters show improvements for the **AMBF** solutions. Estimated orbit parameters for S-1 still show large dependency to eclipse periods.

External SLR validation



External SLR (Satellite Laser Ranging) validation is only possible for Sentinel-3. SLR residuals confirm the improvements for the reprocessed orbit solutions.

Solutions – until end of 2018

- OPER**: Operational Sentinel orbits, IGS Final orbit and clocks used
- REPR**: Reprocessed Sentinel orbits based on reprocessed GPS orbits and clocks
 - Fully consistent with ITRF14/IGS14
 - 36h arc length
- AMBF**: Reprocessed Sentinel orbits based on GRGS Final GPS orbits and clocks used together with the WSB for single-receiver ambiguity-fixing

Correct **GPS ARPs** for **Sentinel-1** used for **AMBF** and **REPR** solutions.

Additional phase center offset (**PCO**) estimation delivered new values for all satellites, used for **AMBF** and **REPR** (only S-1) solutions

Mission	PCO LOCATION (w.r.t. the ARP) - NORTH/EAST/UP [mm]	
	Operational values	Recalibrated values
S-1A	1.00 / -0.50 / 68.00	-11.22 / -1.98 / 59.80
S-1B	1.00 / -0.50 / 68.00	-21.13 / -3.48 / 51.92
S-2A	0.00 / 0.00 / 68.00	0.00 / -0.70 / 70.61
S-2B	0.00 / 0.00 / 68.00	0.00 / -1.02 / 71.81
S-3A	0.00 / 0.00 / 68.00	0.00 / 0.00 / 75.26
S-3B	0.00 / 0.00 / 68.00	0.00 / 0.00 / 72.08

Summary and Outlook

The Copernicus POD Service has done an offline reprocessing for all six Copernicus Sentinel satellites. A fully consistent time series with ITRF14/IGS14 (**REPR**) has been produced and all other updates and improvements made in the CPOD processing since the launch of Sentinel-1A have been included. In addition, single-receiver ambiguity-fixed orbit solutions (**AMBF**) have been generated using the GRGS/CNES WSB product. Comparisons to the operational (**OPER**) orbit solutions show the step-by-step improvements for the different satellites. In the case of Sentinel-1 large differences of several cm are present, because the GPS ARP have been corrected for the reprocessing.

Orbit overlaps do not show unique improvement for **REPR**, but **AMBF** is better than **OPER**. However, additional updates of background models lead to large improvements of the **REPR** orbit overlaps.

External SLR validation confirm the improvements of the reprocessed time series for S-3.

Further analyses of the reprocessed time series are foreseen in particular to understand the different performances of the **REPR** solutions. Updates of background models will also be further investigated. An integration of the reprocessed orbit solutions into the official Sentinel processing procedures at the individual PDGS is a future goal.



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