Copernicus Sentinel-1 satellites – Operational orbit determination at the Copernicus POD Service + Reprocessing



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(1) PosiTim UG, Seeheim-Jugenheim, Germany (2) GMV AD., Tres Cantos, Spain (3) ESA/ESRIN, Frascati, Ital) cesa



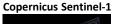


Copernicus POD Service – general information























- Sentinel satellites are equipped with various Earth observation instruments
- Mission requirements demand high levels of orbital accuracy (GPS, DORIS+SLR only S-3 + S-6 (+GAL)) → Copernicus POD Service

Mission	Category	Orbit Accuracy (RMS)
S-1	NRT (predicted)	1 m (2D)
	NRT	10 cm (2D)
	NTC	5 cm (3D) in comparison to external processing facilities



Copernicus POD Service

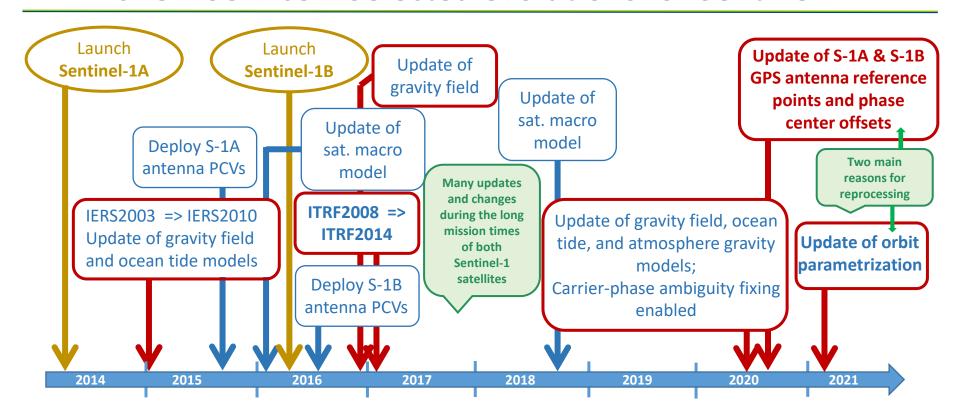
- Consortium led by GMV, Tres Cantos, Spain
- magicGNSS, external GPS orbit and clock provider (NRT, STC), backup **DLR Reticle**
- **PosiTim**, QWG management, quality control, improvements, scientific outreach ...
- **DLR, TUM, AIUB, TUD, GFZ** quality control, QWG members







CPOD Service – Selected evolutions for Sentinel-1









CPOD Service – Planning of reprocessing

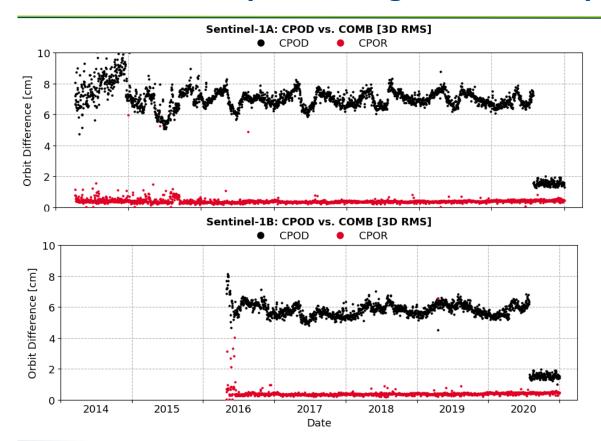
- ITRF2014 / IGS14 compatible GPS orbit, clock and bias (for integer ambiguity resolution (IAR)) product for the entire mission times is needed => CODE (Center for Orbit Determination in Europe) provided IGS14-consistent reprocessed time series of GPS orbits, clocks and biases for the years 2014-2019 (doi: 10.7892/boris.146753).
- For orbit validation and quality control external orbit solutions are needed (no SLR (Satellite Laser Ranging) reflector on the satellites) => Copernicus POD QWG members (AIUB, DLR, ESOC, TUM, TUD) provided Sentinel-1A & -1B reprocessed orbit solutions based on their s/w packages and orbit determination settings for validation.
- A combined orbit solution (IGS-like combination based on weighted average) is computed serving as a reference solution.







Sentinel-1 reprocessing – orbit comparison – old => new



Comparison of combined (based on all reprocessed orbit solutions) vs. operational (CPOD) and reprocessed (CPOR) orbit solution shows large impact of the correction of the GPS antenna reference point and phase center offsets (done in mid-2020)

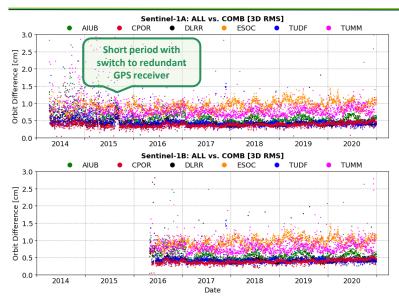
=> Need for reprocessing is more than obvious!



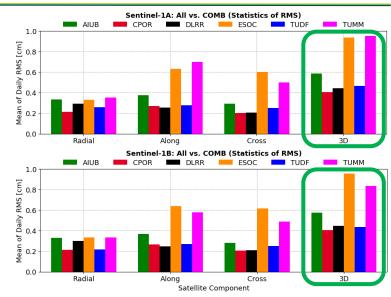




Sentinel-1 reprocessing - orbit comparison



- Comparison of all vs. combined orbit solutions shows an extremely high consistency below 1.5 cm for most of the time.
- Outliers are mainly due to data gaps and manoeuvres, which are handled differently from the groups.
- Seasonal variations dominate orbit differences (eclipse season in summer).



- Despite seasonal systematic differences the overall mean differences are within ± 2 mm (not shown).
- The mean 3D RMS over the entire mission times for both satellites are below 1 cm for all orbit solutions.
- ⇒ Very high consistency of all orbit solutions
- ⇒ Orbit accuracy requirement of < 5cm 3D RMS w.r.t. external orbit solutions is fulfilled with large margin.







Summary and Conclusion

- A full mission reprocessing of the precise orbit products has been performed for the two Copernicus Sentinel-1 satellites (in orbit since April 2014 & 2016, respectively).
- Several model and orbit parameter updates during the last years and, in particular, a correction of the GPS antenna reference point and phase center offsets made this reprocessing necessary.
- Small systematic and seasonal variations in the orbit differences between the groups are still
 present. Further investigations on the satellite macro model are needed to even improve the
 well performing orbit solutions.
- Reprocessed Sentinel-1 orbit solutions from the Copernicus POD Service are available on the Copernicus Data Hub =>

https://sentinel.esa.int/web/sentinel/-/copernicus-sentinel-1a-and-1b-precise-orbital-products-currently-available-for-the-entire-mission/1.2

- As long as the Sentinel-1 SAR products are not reprocessed/regenerated including the reprocessed orbit positions be very careful when processing data before and after 29/30 July 2020 (orbit shift of ~6-7 cm).
- More information about the reprocessing may be found at https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-1-sar/pod/documentation => Sentinel-1 Full Mission Reprocessing (2021).pdf









Questions to the Sentinel-1 orbit products?

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