

Copernicus Sentinel-1 satellites – Nine years of operational orbit determination at the Copernicus POD Service

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Abstract

The Copernicus POD (Precise Orbit Determination) Service is part of the Copernicus Processing Data Ground Segment (PDGS) of the Copernicus Sentinel-1, -2, -3 and -6 missions. The CPOD Service is in charge of generating precise orbital products and auxiliary data files for their use as part of the processing chains of the respective Sentinel PDGS. We present the Copernicus POD Service in terms of operations and orbital accuracy achieved for all orbital products for Sentinel-1A and -1B. Focus is led to the validation of all orbit product lines, recent improvements, and the impact of the switch to **FocusPOD**.

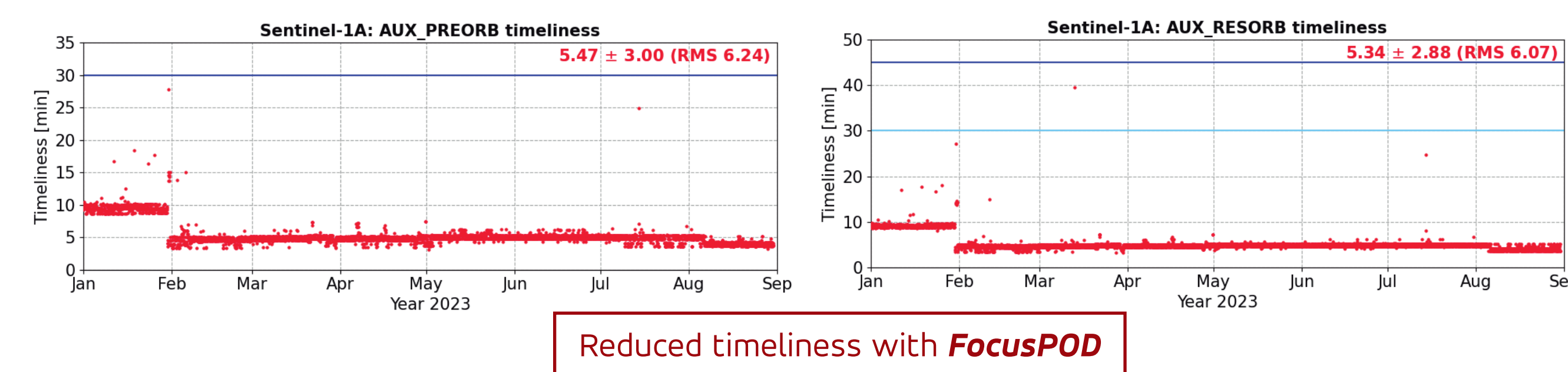
1. Sentinel-1 CPOD Service products performance

- **Product types:** AUX_PREORB (predicted orbits, PRE), AUX_RESORB (near-real time orbits, NRT), AUX_POEORB (non-time critical orbits, NTC), and reprocessed orbits (REP). See Section 3 for more information details in REP orbits.
- **Interval of time:**
 - **Delivery timeliness:** Since beginning of year 2023 (includes deployment of new **FocusPOD** software).
 - **Orbit accuracy:** Since beginning of mission (7th April 2014 for S-1A, and 28th April 2016 for S-1B).
- Sentinel-1B was decommissioned on mid-2022.
- More information on products performance in Sentinel Online (SoL) webpage (see Section 2).

DELIVERY TIMELINESS

The delivery timeliness is computed as the time from the GPS Level-0 availability date until the CPOD product publishing date, which, as seen in the plots below, is **extensively fulfilled**.

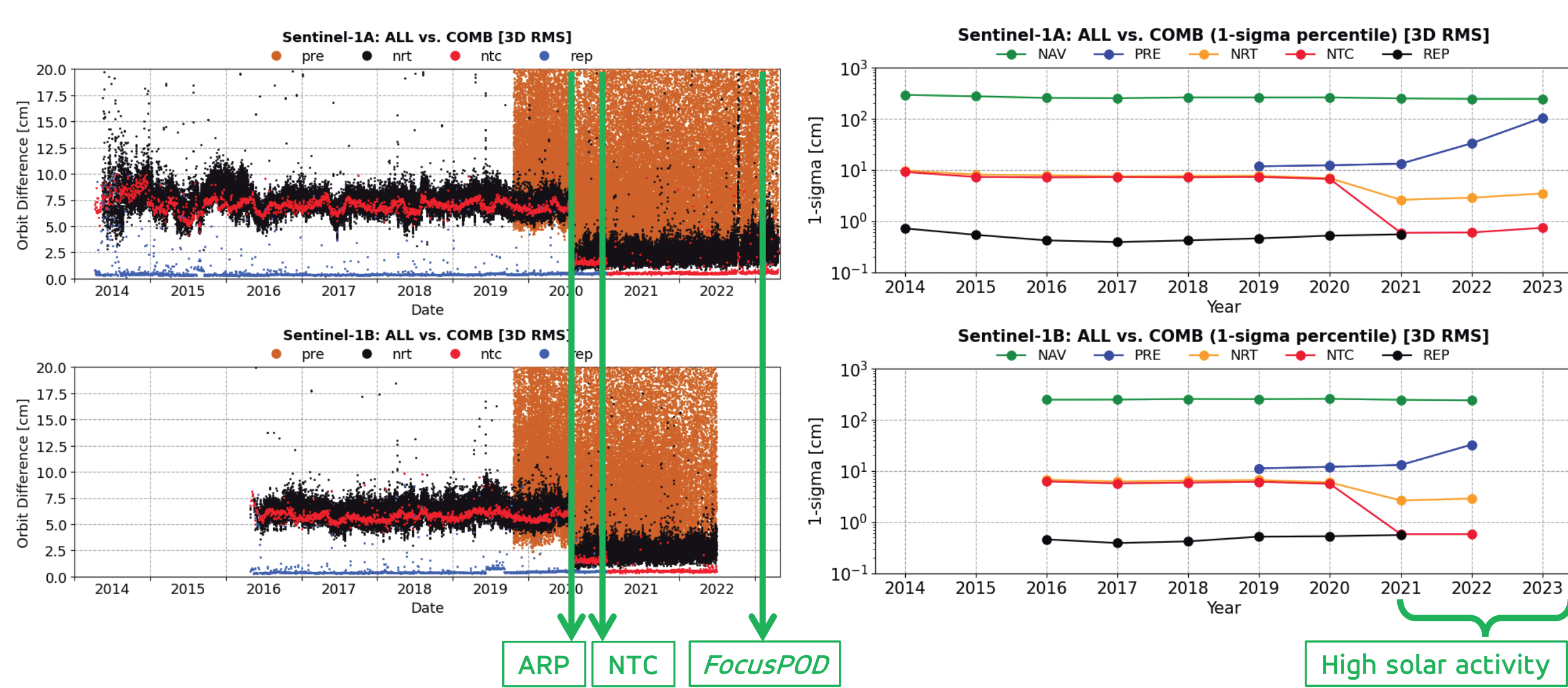
Horizontal blue lines mean the timeliness threshold for each product (light blue lines, if any, stand for a goal timeliness). Mean, standard deviation and root mean square (RMS) values (in min or days) for each product are shown in the plots.



Reduced timeliness with **FocusPOD**

ORBIT ACCURACY

The orbit accuracy plots have been divided per temporal evolution on the left and showing the 1-sigma percentile for each year on the right. All orbit products are compared against a combined orbit solution (COMB), which is built every Regular Service Report (RSR) period of time from a combination of the orbits generated from all centres participating on the CPOD Quality Working Group (QWG).



- A significant accuracy improvement after a change on the Antenna Reference Point (ARP) for both satellites at the end of year 2020.
- An NTC accuracy improvement after the selection of a better-suited dynamic parametrisation at the beginning of year 2021.
- An equal or very similar accuracy performance after the deployment of the new **FocusPOD** software.
- A degradation on the PRE orbit accuracy since year 2021 due to the high solar activity (see more details in Section 4).

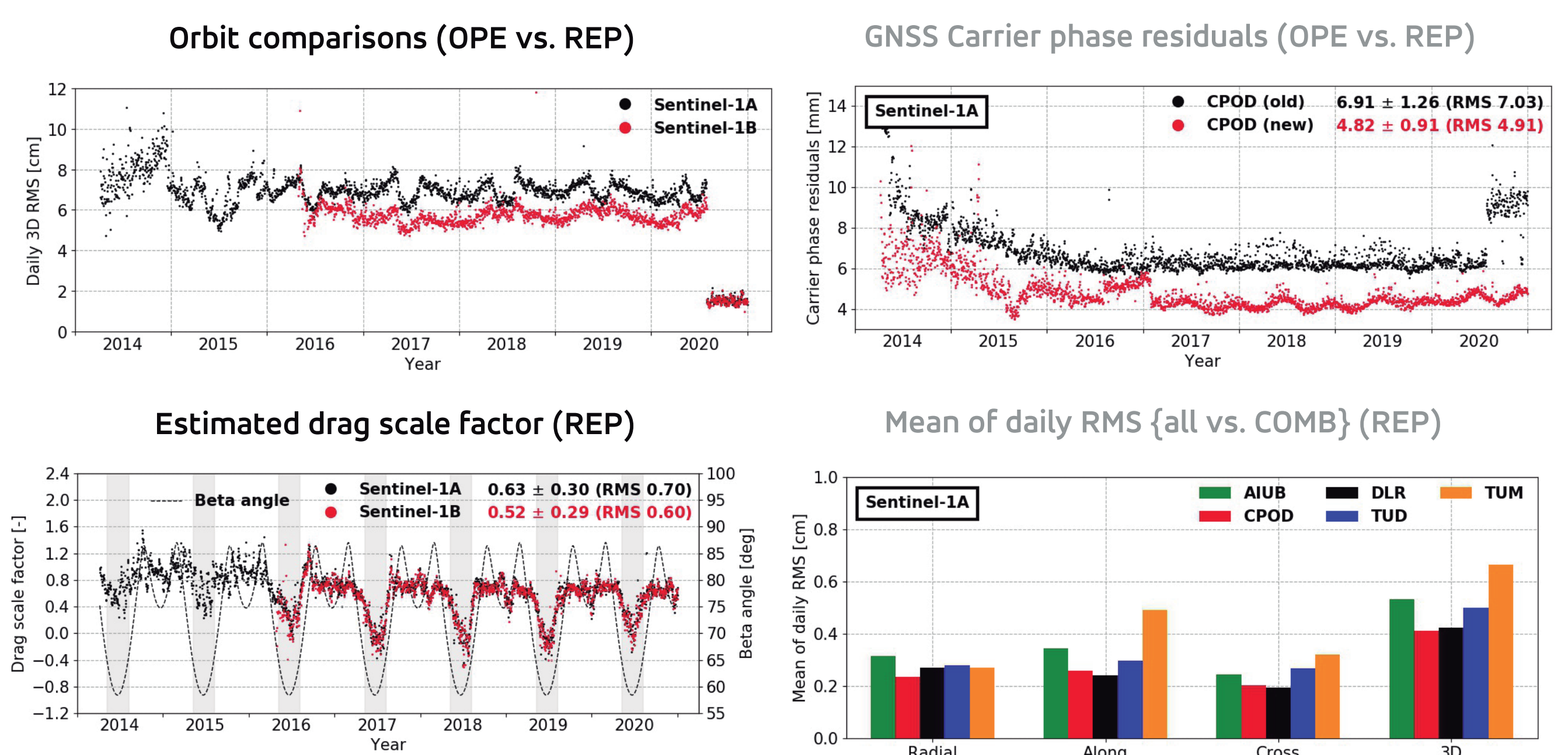
2. CPOD Service products availability

The CPOD Service products (orbits, attitude files and observation RINEX files) are routinely uploaded to the ESA Copernicus Open Access Hub web portal. This web portal will be soon substituted by the Copernicus Data Space Ecosystem, the new ESA's web portal to find the products generated by the CPOD Service on the frame of the Copernicus programme. The CPOD Service will guarantee a smooth transition between the data flow from the old to the new web portal. General information about the CPOD Service, the products uploaded and more may be found in SoL webpage.



3. Sentinel-1 reprocessing campaign

A reprocessing campaign was triggered in 2021 to apply the operational improvements since the beginning of the mission (see orbit accuracy in Section 1). Below, there is an excerpt of the obtained results (the complete analysis may be found in the dedicated paper, see QR code below).



- The results on the estimated drag scale factor lead to further investigate the periods of time when satellite eclipses occur (vertical grey lines).

Sentinel-1
Reprocessing
Paper in ASR
journal

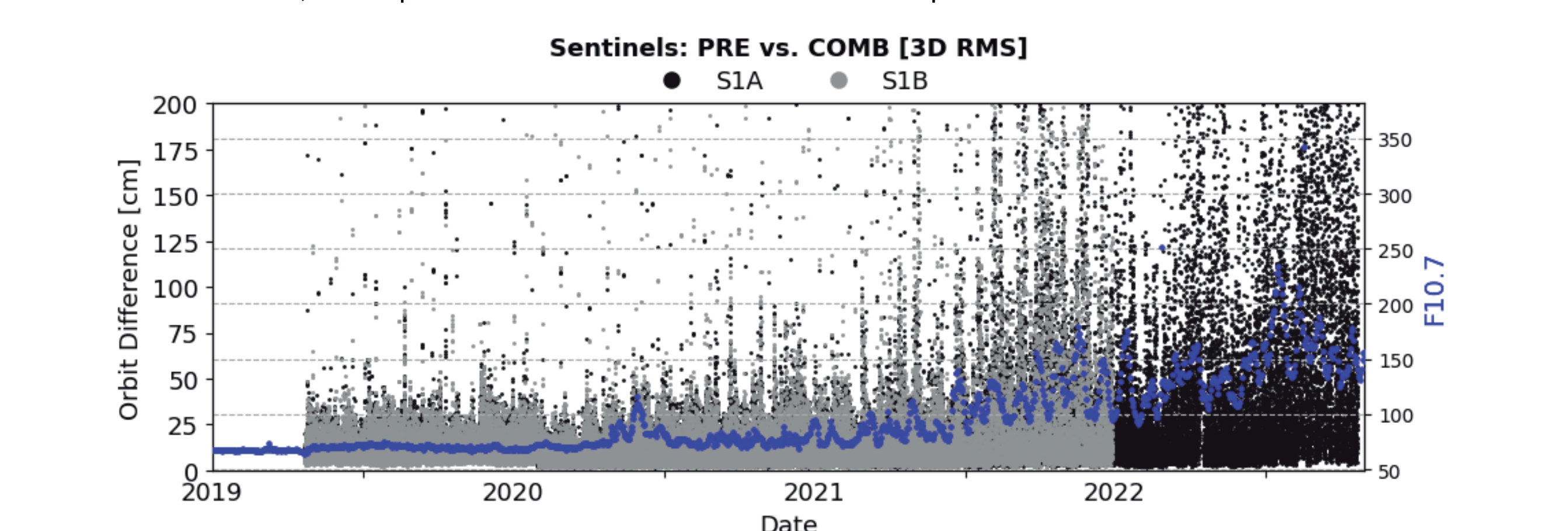


4. Solar activity

The accuracy of the Sentinel-1 PRE orbit products has got worse since year 2021 (increase on solar activity). The plots below show:

- Correlation between orbit worsening and solar activity (parameter F10.7, indicator of the solar radio flux).
- Higher CP residuals with higher solar activity, especially in poles due to ionospheric scintillation.

The geographic plots show the RMS value of all CP residuals falling on each image pixel for the period of time analysed.



5. User interaction: SoL + Quality disclaimers forms

The CPOD Service is working in ways to reduce the impact of the solar activity to the generation of the PRE products. While a solution is found, quality disclaimers forms are going to be generated (in collaboration with ESA) to alert the users of possible quality issues on the products generated by the CPOD Service. Any improvement will be shared with users through a piece of news in SoL webpage.

property	value
last modified	2023-08-02 14:44:59
mission	S1A
description	Products processed using degraded orbit files due to solar activity
product quality status	DEGRADED
degradations	DEGRADED_PRODUCT_GEOLOCATION
degradation percentage	0.0%
validity start	2023-01-15 02:30:48
validity stop	2023-07-22 07:42:56
product types	EW_S1C_15 WW_S1C_15 WW_S1C_15 WW_GRODM_15 WW_GRODM_15
anomaly characterisation report	S-1-QD_159_1.pdf

Acknowledgements

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