COPERNICUS POD SERVICE

IMPROVED SLR ORBIT VALIDATION FOR COPERNICUS SENTINEL-3 MISSION

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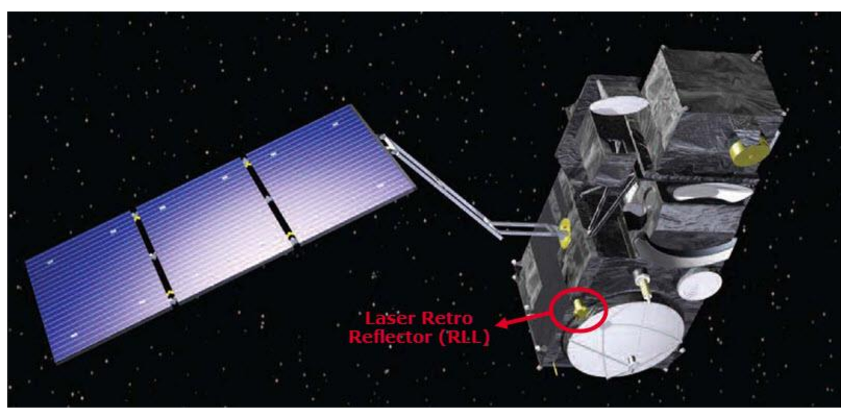
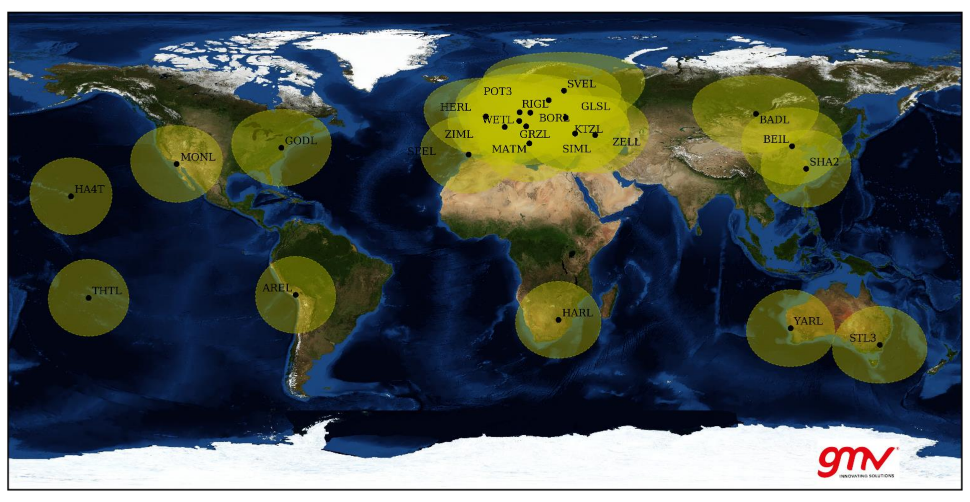
1. ABSTRACT

The European Copernicus Sentinel-3 mission, a jointly operated mission by ESA and EUMETSAT, consists of two satellites equipped with GPS and DORIS receivers, and a Laser Retro Reflector (LRR) array, which allows tracking the satellites by Satellite Laser Ranging (SLR). The SLR observations are mainly used for the validation of GPS- and/or DORIS-derived precise orbit solutions. The SLR residuals are derived from the simple difference between observed and computed range between SLR station and the satellite. Only a subset of the SLR stations tracking the satellites is normally used for this purpose. The subset consists of stations delivering good quality observations on a long-term. The station selection is regularly reviewed to guarantee a continuous quality for the orbit validation.
Instead of using only a subset of the stations it would be preferable to use as many laser tracking data as possible. Long-term and highly accurate orbit time series of low Earth orbiting satellites can be used to estimate station range biases. The SLR validation is significantly improved by adding these station range biases due to additional stations and due to the removal of SLR related systematic patterns.
In the Copernicus POD Service (CPOD), the SLR station range biases are estimated based on combined Sentinel-3A and -3B orbits computed from different orbit providers (the CPOD Quality Working Group). Performance, quality, mission dependency and stability of these SLR station range biases are analysed based on operational CPOD orbits and orbit solutions delivered by the Copernicus POD Quality Working Group.

Sentinel-3 (LRR) — SLR stations (map)

The figure on the left shows the location of the **LRR reflector** on Sentinel-3 satellites. The figure on the right depicts the **geographical location** of the current SLR stations tracking both Sentinel-3 satellites. The table below summarises all **SLR stations that have ever tracked the Sentinel-3 satellites**. The SLR stations highlighted in red are not allowed to track the Sentinel-3 satellites any more, and the ones highlighted in green are the SLR stations used to calculate the outcome presented in this poster.





SLR stations (monument & code)

Mon.	1824	1873	1884	1888	1889	1890	1893	7080	7090	7105	7110	7119	7124	7237
Code	GLSL	SIML	RIGL	SVEL	ZELL	BADL	KTZL	MDOL	YARL	GODL	MONL	HA4T	THTL	CHAL

Mon.	7249	7403	7501	7810	7811	7821	7824	7825	7838	7839	7840	7841	7941	8834
Code	BEIL	AREL	HARL	ZIML	BORL	SHA2	SFEL	STL3	SISL	GRZL	HERL	POT3	MATM	WETL

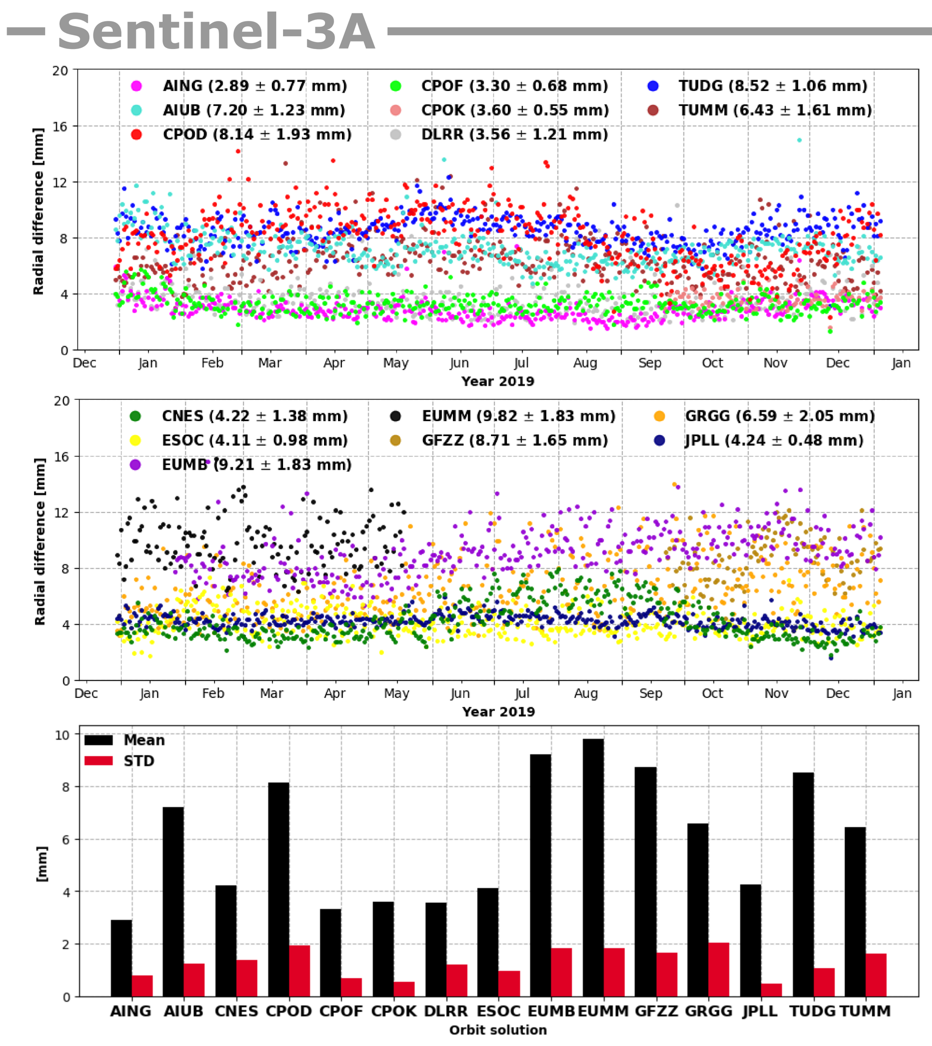
3. SENTINEL-3 COMBINED (COMB) ORBIT SOLUTION

The COMB orbit solution is generated by following an IGS-like approach of all orbit solutions provided by the members of the CPOD Quality Working Group (QWG). Below, there is the list of all centres participating on the CPOD QWG and the list of orbit solutions used to generate the final COMB orbit solution. In addition, some figures have been added to present the **orbit comparisons** between each orbit solution and the resultant COMB orbit solution. These orbital comparisons show the **daily RMS** on the **radial component** during 2019. The last two figures gather the **mean** and **standard deviation** statistics of the mentioned orbit comparisons.

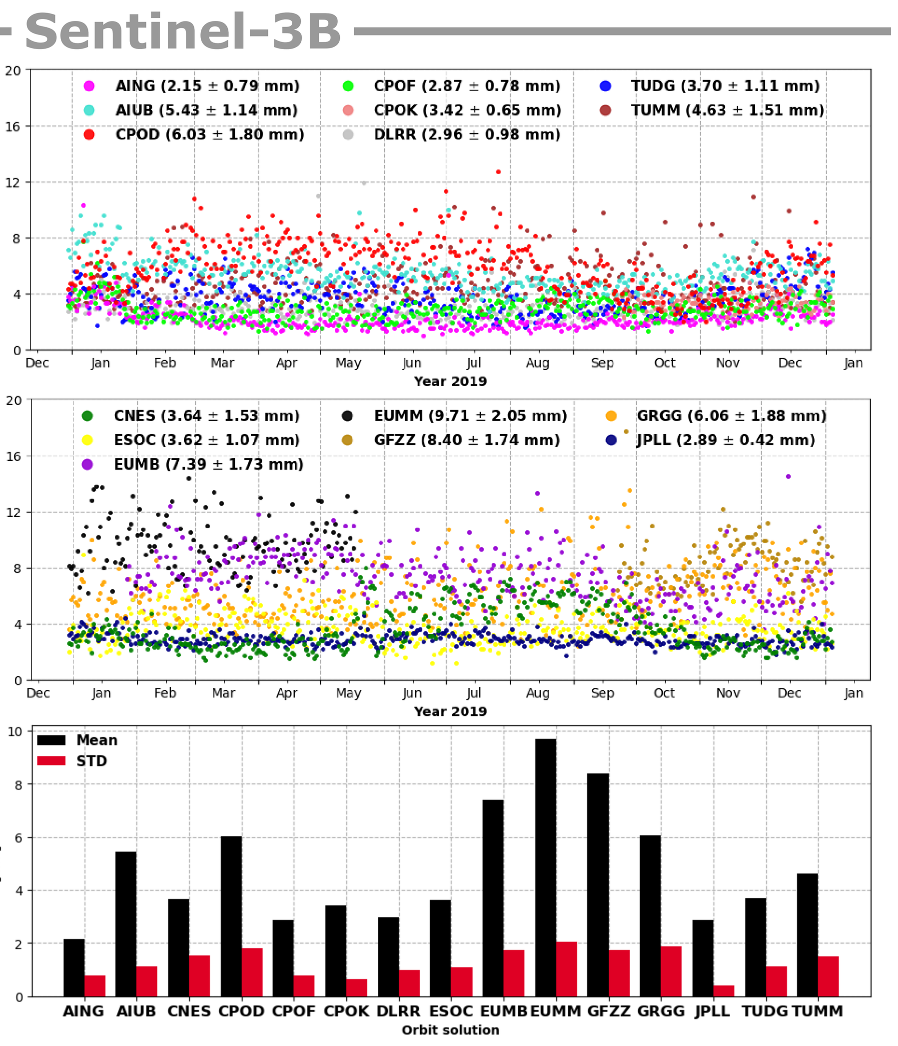
QWG members

Orbit solutions to generate the COMB							
AING	AIUB	CNES	CPOD	CPOF	CPOK	DLRR	ESOC
EUMB	EUMM	GFZZ	GRGG	JPLL	TUDG	TUMM	

Sentinel-3A

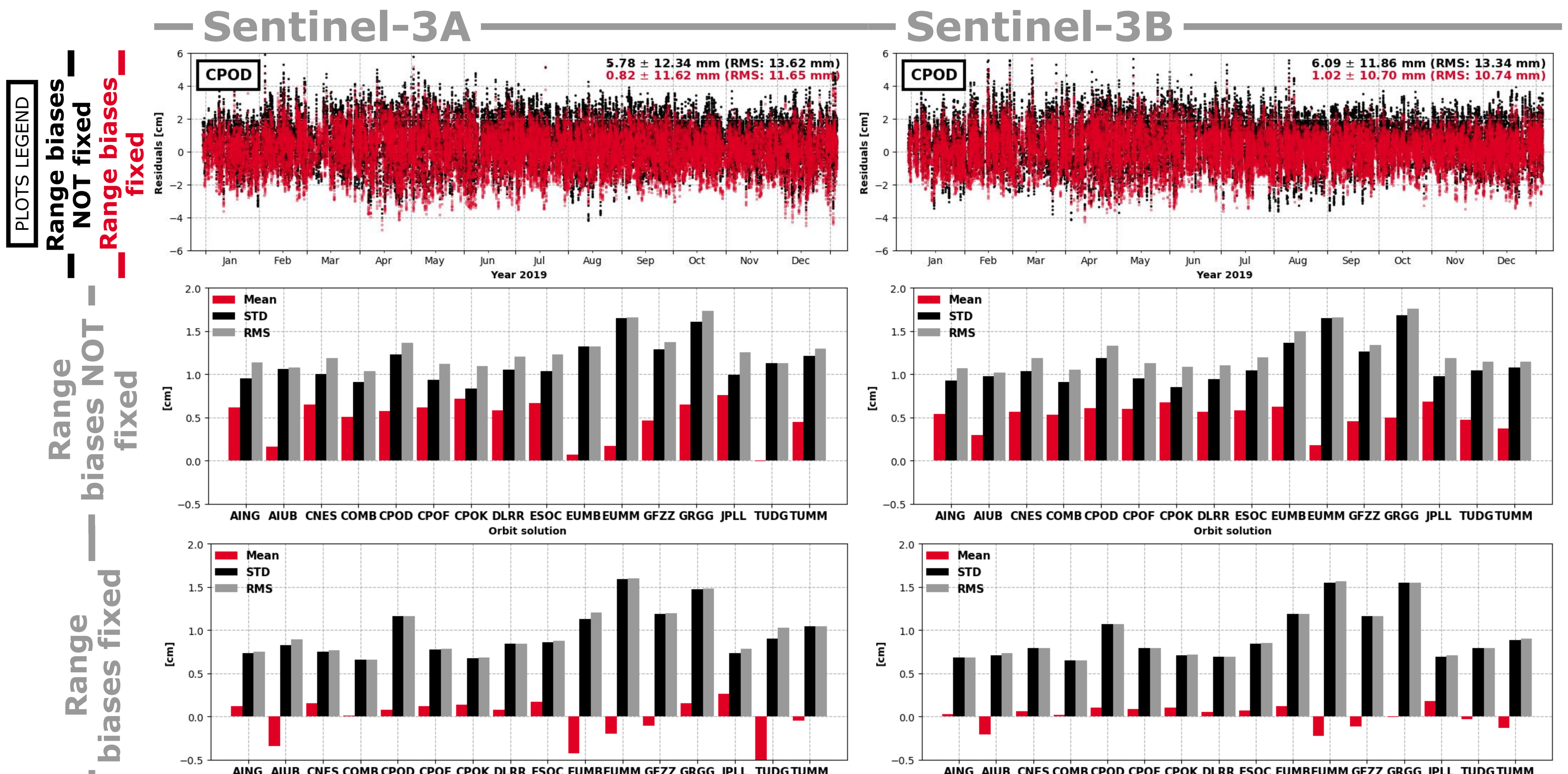


Sentinel-3B



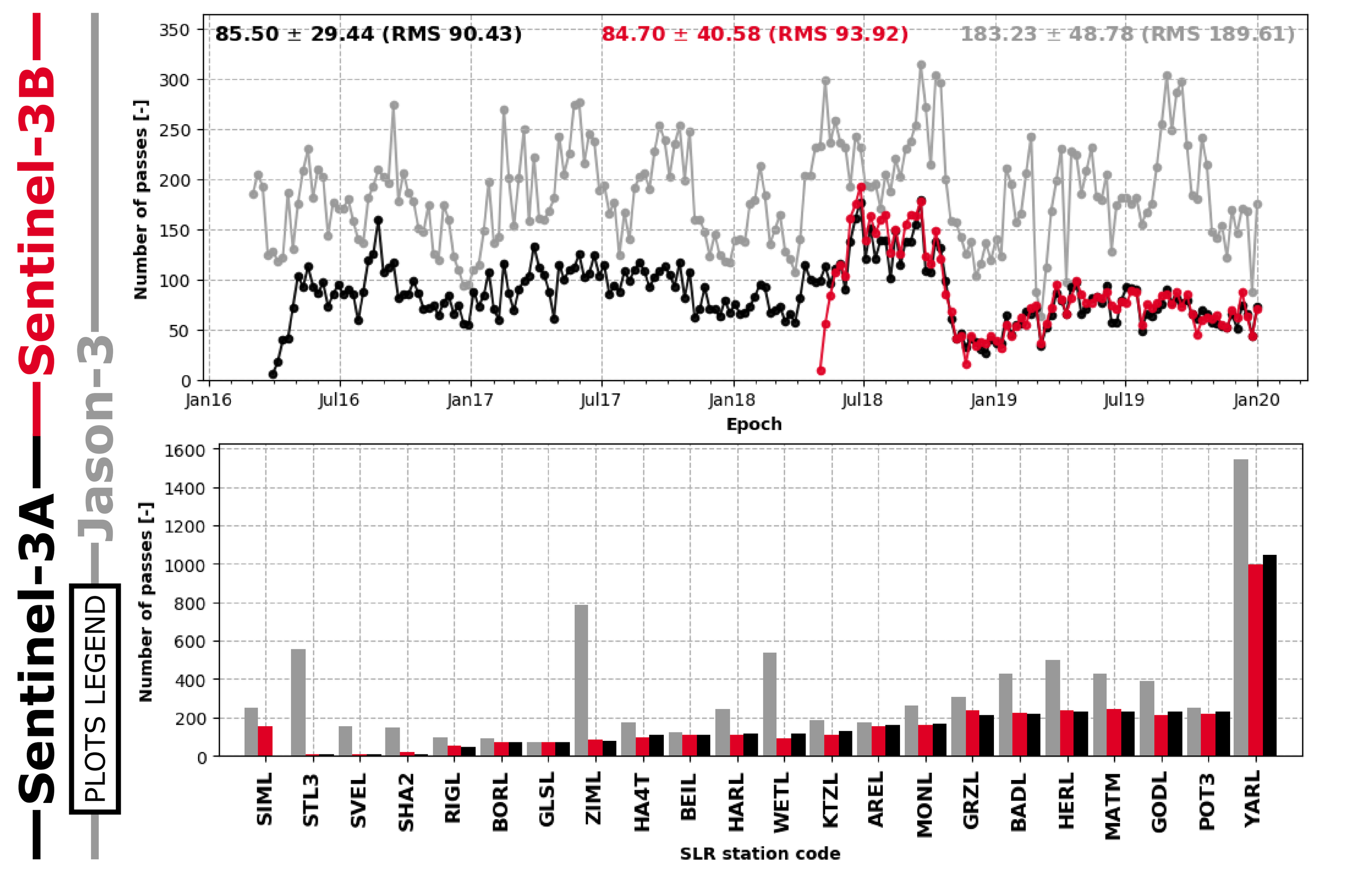
5. SLR RESIDUALS

Applying the range biases estimated (section 4) for each SLR station on the calculation of the SLR residuals clearly benefits the final outcome. An example of the temporal evolution of the SLR residuals for the orbit solution CPOD during 2019 is given below. As seen, the mean value approximates to value zero and both the standard deviation and root mean square values reduce their figures if the range biases are fixed. The statistical figures of all orbit solutions of Section 3 also show an improvement when the range biases are taken into account. The mean value of the SLR residuals is no longer just a positive value for all orbit solutions but oscillates between positive and negative values, and tend to zero for the vast majority of orbit solutions. The standard deviation and root mean square values also diminish for all orbit solutions.



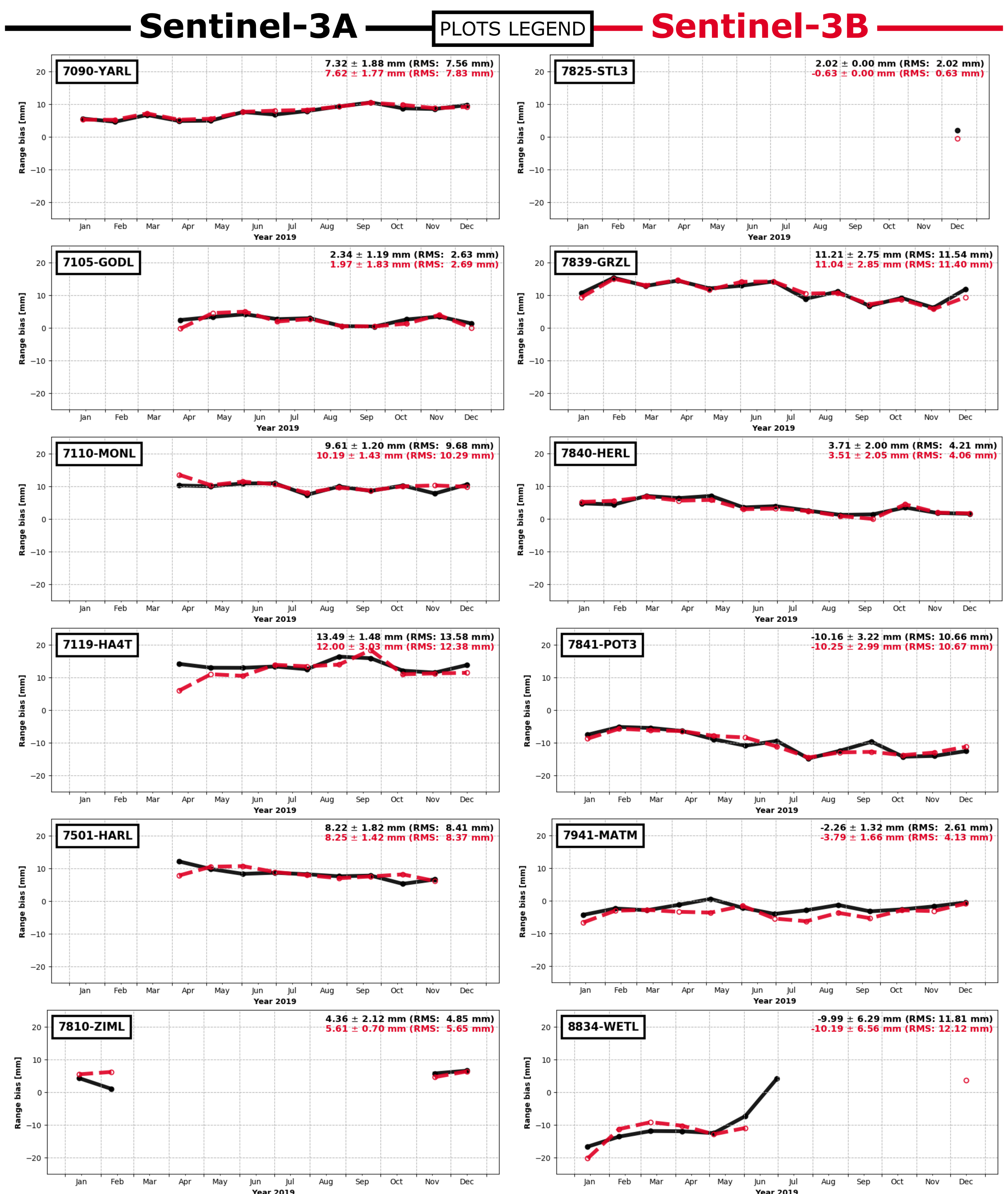
2. SENTINEL-3 SATELLITE PASSES

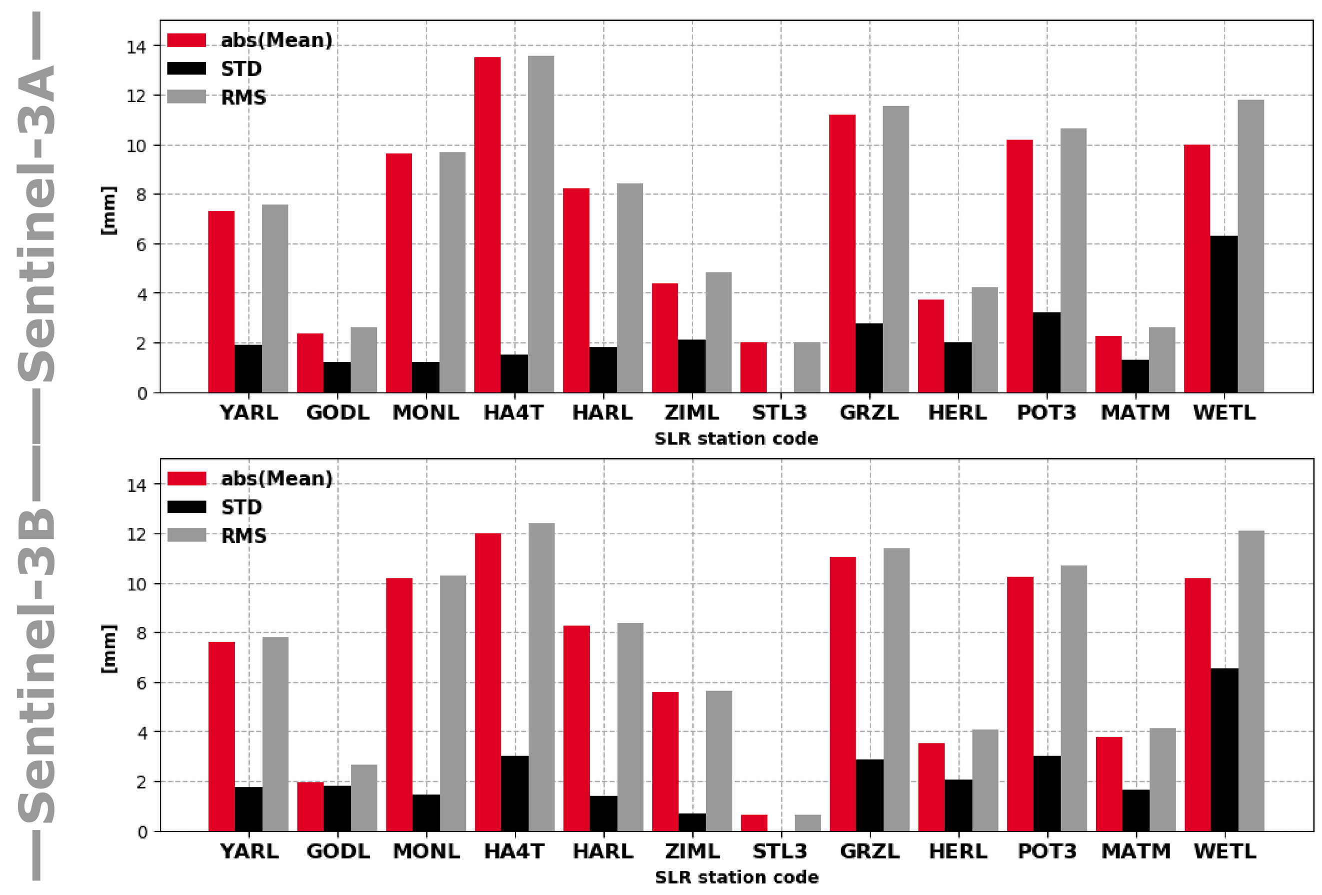
The first figure shows the **total number of satellite passes per GPS week** that all SLR stations tracking Sentinel-3 satellites have provided since the beginning of the satellite mission. The second figure shows the **total number of satellite passes per SLR station** only during 2019.



4. RANGE BIASES ESTIMATION

The following figures depict the **range bias estimation** (one way) of each SLR station used along year 2019. Such biases have been calculated by fixing the COMB orbit solution of Section 3 on sets of 4-GPS-week time periods. Independent range biases are computed per satellite. This plots not only shows the biases, but also its stability.





6. CONCLUSIONS & FUTURE WORK

The use of the estimated range biases of the SLR stations improves the independent validation of the GNSS/DORIS –based orbital products.
It must be taken into account that the orbit solution to calculate the biases has been generated as a combination of several orbit solutions from different centres, which makes use of different processing schemes, models and software.
The calculation of the range biases could be done using simultaneously several satellites, in order to find a common range biases pattern amongst different satellite missions.

Periodic orbit validation of the Sentinel-3 mission can be found in the "Copernicus POD Regular Service Review" documents, which are published on the Sentinel Online website.
https://sentinels.copernicus.eu/web/sentinel/

Acknowledgements

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