Sentinel-1 instruments status and product performance update for 2023

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Abstract

The Copernicus program [1] and particularly Sentinel-1 [2] are among the largest Earth Observation SAR data providers, serving an ever-increasing number of services, users, and applications. A key aspect of the program is the constant provision of quality data, which requires long term engagement to carefully monitor, preserve, and even improve the system performances.
These tasks are mainly carried out within the Sentinel-1 Mission Performance Cluster (S-1 MPC), an international consortium of SAR experts in charge of the continuous monitoring of the S-1 instruments status and of the L1 and L2 products quality. The S-1 MPC is responsible of detecting any potential issues and implementing the necessary actions to ensure that no data quality degradation occurs for the users [3].

This paper provides an update on the monitoring and the actions implemented by the S-1 MPC during the 2022. As the end of mission for S-1B has officially been announced [4] after it suffered an anomaly resulting in its unavailability since the 23rd December 2021, this paper concerns only the performances of S-1A. The analysis regards the following topics:

- **Instrument status:** The gains and phases of the 280 individual Transmit Receive Modules (TRMs) composing the antenna are monitored via the RFC products to look for instrument aging or elements failures. Although this type of damage has occurred in the past, prompting for an electronic reconfiguration, the antenna status of S-1A has been stable throughout the 2022, see **Fig. 1**. The instrument status is monitored via internal calibration products, describing the evolution of the product gain (PG) in time, and via noise products. The instrument pointing is also monitored by means of the Doppler Centroid estimates annotated in the L1 products.
- **Radiometric accuracy**: The instrument is radiometrically calibrated both in absolute and relative terms. Acquisitions over a calibration site comprising of both transponders and corner reflectors allow for the assessment of the absolute calibration constant. The relative calibration is performed by considering acquisitions over a distributed target such as the rainforest, over which the gamma profile is assumed to be flat with respect to incidence angle.
- **Geolocation accuracy:** It is monitored through the analysis of acquisitions over calibration sites consisting of stable point targets with known reference coordinates [5]. The range-Doppler position of the targets measured by the system is compared against the expected position derived from the available orbit information and the accurately characterized target coordinates. Corrections are applied to compensate for known instrument effects, for the atmospheric delay, and for the targets' displacement due to solid Earth tides. Eventually, the Absolute Localization Errors in azimuth and range are obtained for each target in the analysed acquisitions.
- **Updates on the S-1 Instrument Processing Facility (IPF)** [6] : Since version 3.4, the IPF introduced the annotation of burst cycle ID numbers for the TOPS (Terrain Observation with Progressive Scans) modes [7][8]. The burst cycle ID is a number that uniquely identifies a burst within each repeat cycle. Each burst of a given sub-swath is labelled by a unique and incremental burst cycle ID repeating itself every 12 days. As S-1 bursts are synchronized from pass to pass, a correspondence can be made between the burst cycle ID of a given sub swath and a region on Earth's surface. The annotation of the burst cycle ID was introduced to simplify the search of a specific ROI over time and to aid the creation of interferometric stacks.
  To expand on the use of the burst IDs, the S-1 MPC has published a set of Burst ID maps [9], in which each burst ID is associated to a geolocated polygon delimitating the footprint of the corresponding burst. The maps also specify, for each burst, the sub-swath name, the relative orbit number, the orbit direction (ascending or descending), and the nominal time at which the burst starts. The maps are provided both as sqlite3 databases (one for each acquisition mode), and as KMZ files (one for each acquisition mode and for each relative orbit). See Fig. 2 for an example of the Burst ID map.

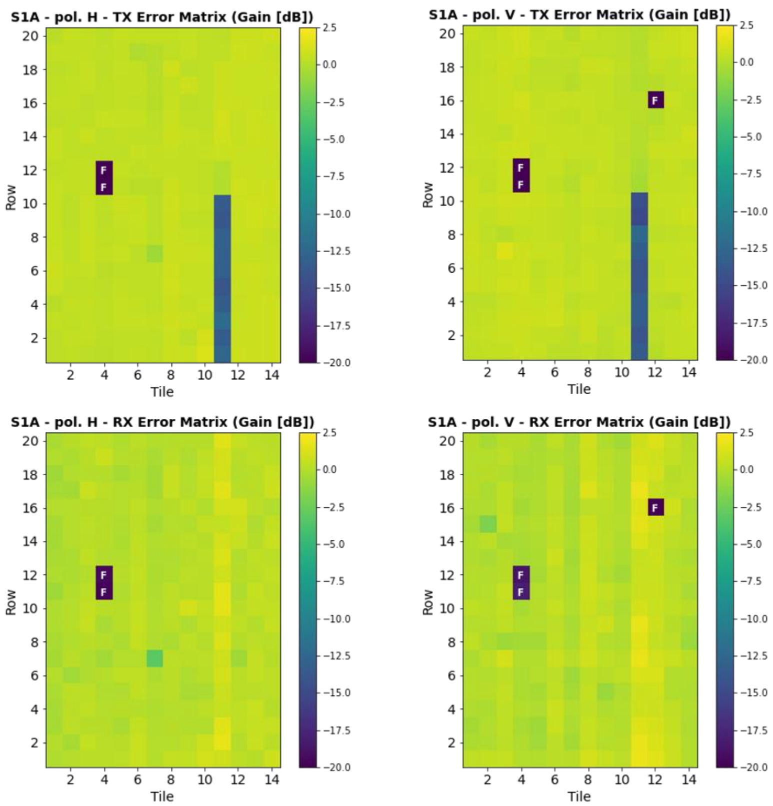

Fig. 1 Sentinel-1A antenna TRMs gains averaged over the month of December 2022. TRMs marked with the letter F have suffered a failure in previous years.

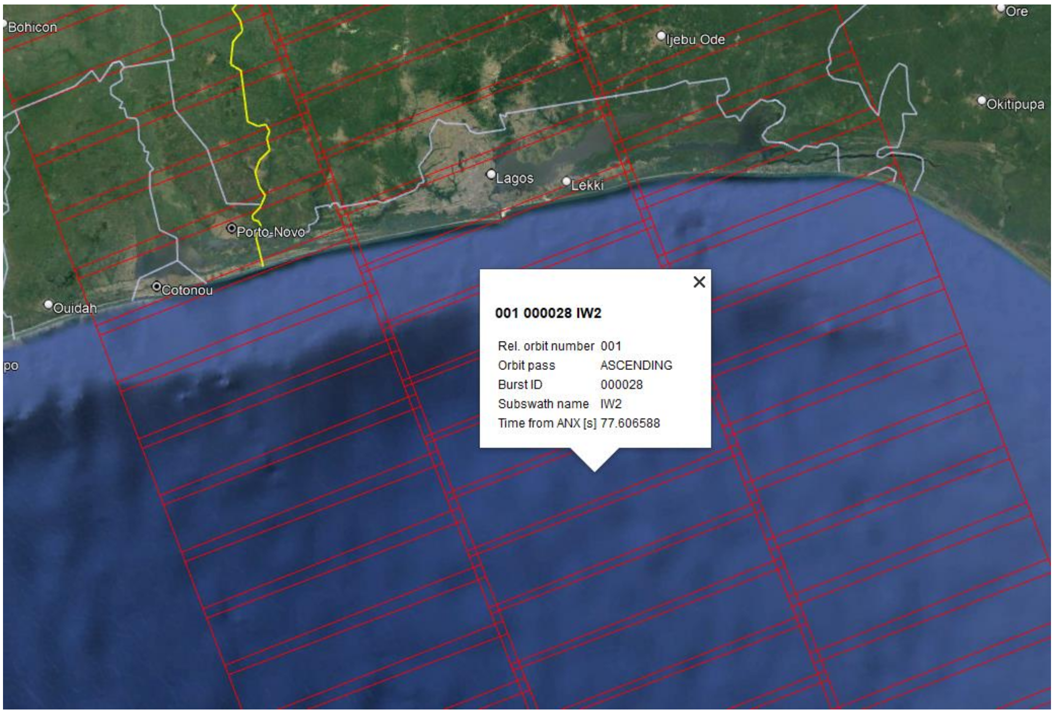

Fig. 2 Example of the Burst ID map for the IW acquisition mode plotted over a map of Earth. The white window shows the data associated with the selected burst.

References

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