Recent developments in Sentinel-1 geometric calibration – A report by SAR MPC ESL GeoCal

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The Copernicus program [1] and particularly Sentinel-1 (S-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 SAR Mission Performance Cluster (SAR 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 SAR 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]. One of the SAR MPC sub-groups is the expert support lab on geometric calibration (ESL GeoCal) which performs monitoring of the mission's geometric performance over dedicated calibration sites such as the corner reflector array at Surat Basin, Australia. The results are regularly published in the S-1 N-cyclic reports and the annual performance reports [3].

One of our recent ESL GeoCal activities involved fine-tuning of the Sentinel-1A (S-1A) and Sentinel-1B (S-1B) instrument delay constants which was motivated by the production start of the Extended Timing Annotation Dataset (ETAD) [4]. The ETAD product contains ready-to-use gridded timing corrections to facilitate straightforward compensation of tropospheric and ionospheric path delays, solid Earth tidal deformations, and effects of SAR processor approximations in S-1 level 1 image products. Overall accuracy (1 sigma) of ETAD is specified as 0.2 m in range and 0.1 m in azimuth, requiring a careful calibration of any remaining instrument biases and other effects not accounted for by the corrections.

The timing calibration constants of S-1A and S-1B sensors originally applied with ETAD products stem from a calibration campaign that used 3 years of IW data from the Metsähovi Observatory calibration site in Finland [4], but centimetre-level offsets in absolute location error (ALE) were still present when analysing different globally distributed validation sites, as observed in the regular mission monitoring of SAR-MPC [5]. The recently performed refinement of the timing calibration involved more sites, the re-processed precise orbits of Sentinel-1 mission, and 5.5 years of data coverage with S-1A and S-1B sensors. Compared to our previous solution, the range timing calibrations change by 6 cm for S-1A and 3 cm for S-1B, mainly due to the re-processed Sentinel-1 precise orbit solution and the usage of more data across multiple reference sites. The S-1A and S-1B azimuth timing calibrations change by 4 cm and 10 cm, respectively.

Our validation activities of the refined calibration values confirm that S-1 range geolocation errors with Interferometric Wide-swath (IW) data are generally reduced to 4 cm or better. For the azimuth ALE of S-1B, offsets observed in certain targets can remain as large as 10 cm but are generally 5 cm or better. For S-1A, the overall azimuth timing calibration is limited by the sensor's known inhomogeneous azimuth characteristics in the different IW sub-swaths. Therefore, ALE offsets of up to 30 cm may still be present in S-1A azimuth IW data when using the refined timing calibration.

In our presentation we will summarize the calibration activity and report on the validation of S-1 across a wide range of point targets and sites. The refined calibration data will become accessible to users as part of S-1 ETAD products, for which public dissemination is planned for Q3/2023, and by the auxiliary

instrument calibration product (AUX ITC) of the ETAD processor which will be published separately on the SAR MPC website.

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