New product evolution of ESA's Extended Timing Annotation Dataset (ETAD) for Sentinel-1 mission

V. Navarro (1), C. Gisinger (1), H. Breit (1), U. Balss (1), S. Suchandt (1), L. Krieger (1), T. Fritz (1), A. Valentino (2), M. Pinheiro (3), G. Hajduch (4)

1 DLR, Germany

2 Rhea for ESA, Italy

3 ESA, Italy

4 CLS, France

First Author Information:

Victor Navarro - victor.navarrosanchez@dlr.de, Phone +49 8153 28-4517, German Aerospace Center (DLR), Remote Sensing Technology Institute, Münchener Str. 20, 82234 Weßling.

Topics: C.06.01 Sentinel-1 mission performance and product evolution

Presentation preference: Poster

SAR remote sensing is a powerful tool for Earth observation, supporting a wide range of applications thanks to its night and day observation capabilities and its excellent geometric accuracy. These include interferometric applications (InSAR), where the differential phase obtained from images of the same area acquired with a different geometry and/or at a different time instant is exploited to reconstruct, for instance, the scene topography or deformation over time.

SAR measurements are, however, affected by the spatial and temporal variability of atmospheric conditions, solid Earth dynamic effects, and approximations during image processing. If not corrected, these effects can produce geometric shifts of up to several meters.

In order to facilitate Sentinel-1 (S-1) SAR data corrections, bringing their geometric accuracy from meters down to centimetres, the Extended Timing Annotation Dataset (ETAD) was developed in a joint effort by ESA and DLR [1][2]. The ETAD product provides easy-to-use gridded timing corrections for S-1 level-1, single-look complex (SLC) data, following the radar geometry of the associated SLC product (range-time, azimuth-time). At the time of writing, ETAD products from July 21th, 2023 onwards can be retrieved via the Copernicus Data Space Ecosystem.

Following positive feedback from the expert users who participated in S-1 ETAD pilot study activities, acknowledged below, an extension of the S1-ETAD baseline product to cover a wider range of applications has been investigated in the context of ESA-funded activity "Scientific Evolution of the S1-ETAD product" (ETAD-SE). Of the experimental features prototyped and evaluated in the ETAD-SE activity, the following features have been selected for inclusion in the operational ETAD processor in the next major release (3.0):

- New correction layer: ocean tidal loading (OTL) corrections in range and azimuth
- New supportive layer: tropospheric delay gradient layer with respect to height changes

- Bit quantization of correction layers in ETAD NetCDF to reduce product file sizes

Ocean tidal loading is a wide-area deformation effect caused by the tidal redistribution of ocean water mass which loads and deforms the solid Earth in coastal regions by up to 10 cm. OTL corrections are expected to improve geometric accuracy in affected coastal regions, also reducing the stochastic error in time series analysis [3].

The tropospheric delay derivative with respect to height is an auxiliary layer to support interpolation of tropospheric delay corrections, highly dependent on surface height, to a new grid with different sampling of the underlying topography. This is useful, for instance, for InSAR applications where secondary products must be aligned (coregistered) to the primary product and, consequently, corrections must be re-evaluated for the common InSAR grid height values [4].

Finally, the bit quantization feature would allow removing non-significant digits from selected layers, ensuring that relevant information is kept, which in combination with data compression algorithms will reduce data size, thus compensating for additional layers in the product. Current product size is in the order of 100 MB.

The implementation and qualification of these new features is foreseen within Q1/2025, in the context of Mission Performance Cluster (MPC) service activities. The new version of the ETAD processor (3.00) is planned to become operational in the S-1 ground segment before May 2025 along with the introduction of Sentinel-1C unit. Our contribution at the LPS'25 conference will present the extended ETAD product, together with use-case scenarios and the status of operational production.

Acknowledgements

The authors thank all the research groups that participated in the ETAD pilot study in 2022, for their valuable feedback on the product when applying it in SAR applications such as offset tracking, InSAR processing, data geolocation and geocoding, and stack co-registration. The ETAD processor was hosted in the Geohazard Exploitation Platform to allow for processing by the pilot participants and the hosting was supported by ESA Network of Resources Initiative. List of participating institutions in alphabetical order: Caltech, DIAN srl, DLR, ENVEO, IREA-CNR, JPL, Joanneum Research, NORCE, PPO.labs, TRE ALTAMIRA, University of Jena, University of Leeds, University of Strasbourg.

The S1-ETAD scientific evolution study, contract No. 4000126567/19/I-BG, was financed by the Copernicus Programme of the European Union implemented by ESA.

The results presented here are outcome of the ESA contract Sentinel-1 / SAR Mission Performance Cluster Service 4000135998/21/I BG. Copernicus Sentinel-1 mission is funded by the EU and ESA.

Views and opinion expressed are however those of the author(s) only and the European Commission and/or ESA cannot be held responsible for any use which may be made of the information contained therein.

[1] Gisinger, C., Libert, L., Marinkovic, P., Krieger, L., Larsen, Y., Valentino, A., Breit, H., Balss, U., Suchandt, S., Nagler, T., Eineder, M., Miranda, N.: The Extended Timing Annotation Dataset for Sentinel-1 - Product Description and First Evaluation Results. IEEE Transactions on Geoscience and Remote Sensing, vol. 60, pp. 1-22, 2022. doi: 10.1109/TGRS.2022.3194216

[2] ESA: Sentinel-1 Extended Timing Annotation Dataset (ETAD). Data product website on Sentinel-1 webpage: https://sentiwiki.copernicus.eu/web/s1-products

[3] Yu, C., Penna, N. T., Li, Z., “Ocean tide loading effects on InSAR observations over wide regions,” in Geophysical Research Letters, 47, 2020. Doi: 10.1029/2020GL088184

[4] Navarro, V., Gisinger, C., Brcic, R., Suchandt, S., Krieger, L., Fritz, T., Valentino, A., Pinheiro, M., "Advancing Sentinel-1 Insar Applications Using Esa’s Extended Timing Annotation Dataset Product," 2023 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Pasadena, CA, USA, 2023, pp. 7878-7881, doi: 10.1109/IGARSS52108.2023.10282172.