New Product Evolution Of ESA's Extended Timing Annotation Dataset (ETAD) For Sentinel-1 Mission

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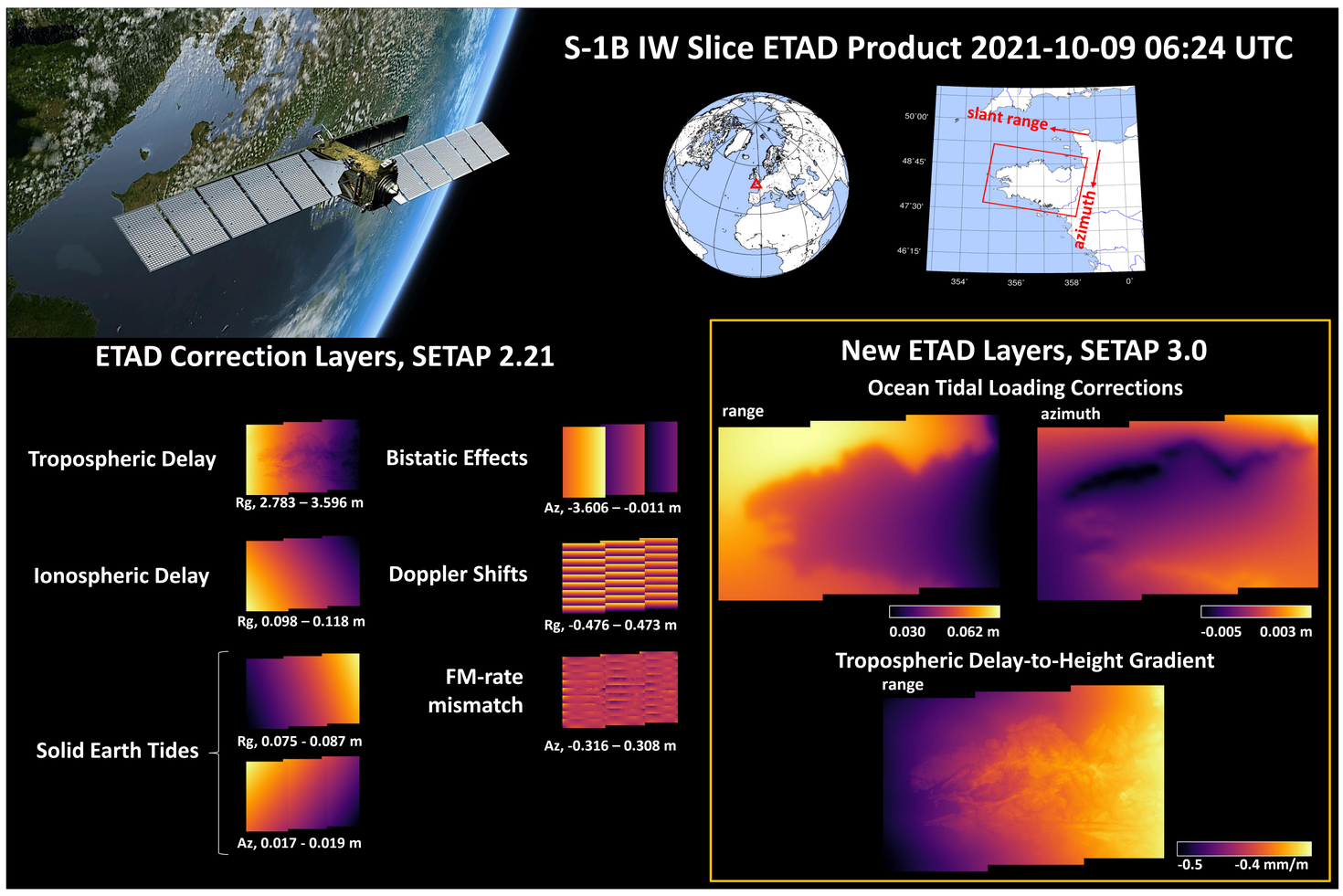


Fig. 1 ETAD correction layers for a Sentinel-1 Interferometric Wide Swath product acquired at Brittany, France. New correction layers introduced in processor version SETAP 3.0 are highlighted: ocean tidal loading corrections in range and azimuth, and a supportive layer representing the tropospheric delay derivative with respect to height. For the visualizations, the timing corrections were converted from seconds to meters.

The ETAD Product

The ETAD product is a joint development of ESA and DLR. It provides users with **timing corrections** for the Sentinel-1 level 1 image annotation to compensate for perturbing **geophysical effects** and **SAR processing effects** (cf. Fig. 1). ETAD base resolution is equivalent to 200 meters. The product **mirrors the SAR image products** and is applied by subtracting the upsampled sum of corrections from the SAR range and azimuth timing grids.

Geolocation accuracy requirement of the Sentinel-1 single-look slant range complex (SLC) products.

Product	Nominal		with ETAD	
	Rg	Az	Rg	Az
TOPS IW	7.0m	7.0m	0.2m	0.1m
Stripmap	2.5m	2.5m	0.2m	0.1m

The corrections are computed with a latency of 20 days - or 11 days with the MOE orbit - leveraging data from ECMWF weather models, GNSS-based total electron content (TEC) maps, geophysical models and parameters of the given SAR acquisition.

ETAD products are **public** since Aug 2023 in the **Copernicus Data Space Ecosystem** platform (CDSE). More details are available at: **https://dataspace.copernicus.eu/**

Evolution of the ETAD product

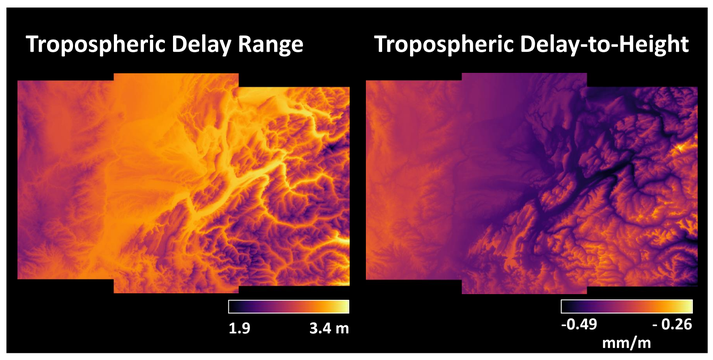
The ETAD processor (SETAP) is constantly evolving to improve its **performance** and **stability** and to introduce **new features**. Based on expert user feedback from the S-1 ETAD pilot study and an ESA-funded initiative on evolving the product, SAR-MPC carried out an extension of the S1-ETAD baseline product for broader applications.

The **features selected for inclusion** in the next version of ETAD are:

- **Ocean tidal loading** (OTL) corrections in range and azimuth
- New supportive layer: **tropospheric delay gradient** layer with respect to height changes, to enhance **InSAR applications**.

Additionally, configurable data quantization of ETAD NetCDF layers is introduced to reduce product file sizes to ~ 70 MB while maintaining the quality of corrections.

Fig. 2 Example of Tropospheric Delay and Gradient obtained over alpine area, European Alps 2020-09-08



The **ocean tidal loading effect** is very prominent in certain coastal regions, e.g. Brittany in France (geometric shifts up to 10 cm). Examples of OTL layers in range and azimuth are shown in Fig. 1.

For **InSAR applications**, ETAD tropospheric delays can cause **artifacts in mountainous areas** if the different sampling of topography between individual ETAD products is not considered during differential phase screen formation. The **gradient layer** ∇Tro allows for a simple **vertical adjustment** of the **tropospheric delay** ΔTro for a given image pair (1,2) before lateral interpolation

$$\Delta Tro_{2,adjust} = \Delta Tro_2 + \nabla Tro_2 \cdot \Delta h_{1,2}$$

The outcome are **artifact-free differential ETAD phase screens** as illustrated in Fig. 3.

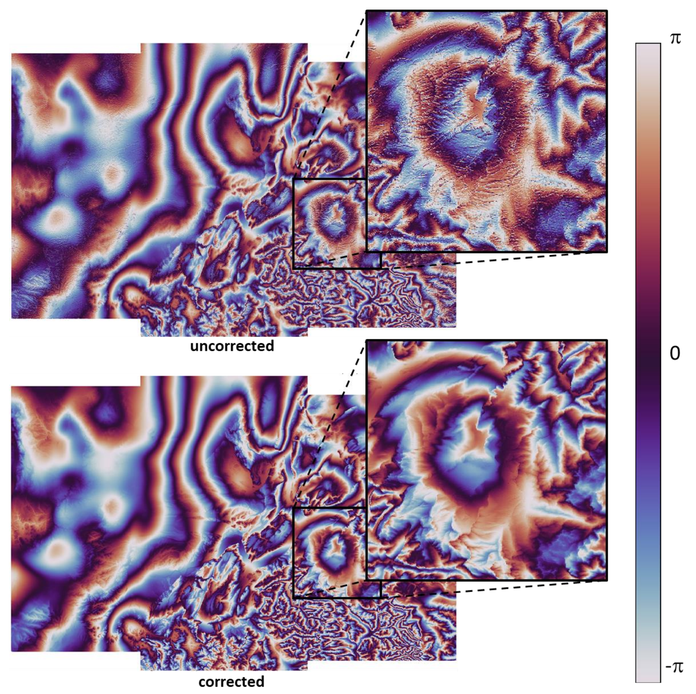


Fig. 3 Differential tropospheric phase from two ETAD products over Alps area, 2020-08-15 and 2020-09-08, with and without adjustment. The wrapped phase corresponds to a range difference of 0.03 to -0.13 m. The gradient layer used for correction is shown in Fig. 2.

Production Status & Dissemination

The new features will be available starting from **SETAP 3.0** planned for release **June 2025**. Dissemination of the ETAD products generated with the new processor version will begin shortly after in the **CDSE platform**. The integration to SNAP is being prepared as well.

For more information on ETAD visit Copernicus SentiWiki

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