Evaluation of ESA's Extended Timing Annotation Dataset (ETAD) for Sentinel-1 – First Results for Ice Velocity Monitoring and InSAR Applications in Greenland, Iceland and Norway

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SAR images benefit from excellent geometric accuracy due to accurate time measurements in range and precise orbit determination in azimuth. Moreover, the interferometric phase of each single pixel can be exploited to achieve differential range measurements for the reconstruction of topography and the observation of earth surface deformation and surface motions. But these measurements are influenced by the spatial and temporal variability of the atmospheric conditions, by Earth dynamics, and by SAR processor approximations, which may lead to overall displacements shifts of up to several meters. These effects become visible in various SAR applications including the retrieval of ice velocity applying offset tracking and various InSAR applications, which might require several post-processing steps and external information for correction.

In this paper we present the Extended Timing Annotation Dataset (ETAD) for Sentinel-1 recently developed in a joint effort by ESA and DLR based on research results and processor prototypes available at DLR [1-3]. ETAD is a novel and flexible product for correcting the SAR fast and slow time annotations in standard Sentinel-1 IWS TOPS products. It accounts for the most relevant effects including tropospheric delays based on 3D ECMWF operational analysis data, ionospheric delays based on TEC maps inferred from GNSS, solid Earth tides calculated following geodetic conventions, and corrections of IPF SAR processor approximations. The data are converted to range and azimuth time corrections and are provided in a 200 m resolution grid matching the burst outline of Sentinel-1 TOPS mode data. The processor to compute the ETAD product is now ready to be integrated into S-1 operational environment and to validate the products.

The impact of the ETAD product is evaluated by two applications exploiting widely used techniques, namely SAR interferometry and feature tracking (FT) applied for monitoring velocity on ice sheets and ice caps [4]. In the first part of the evaluation experiment we tested the impact on the retrieval of ice velocity products using FT in Greenland ice sheet and Iceland glaciers and non-glaciated areas. The time correction was applied on burst-level to the Sentinel-1 image pairs before offset tracking processing, and alternatively as a post processing step to correct the offset tracking results. Both methods provided similar level of improvements and showing almost unbiased displacement measurements which was validated for stable terrain. Large scale biases in the results were removed in all cases leading to reduced velocity errors, especially for short 6-day baselines. This potentially reduces the uncertainty for ice velocity retrieval for Greenland and Antarctic ice sheet where stable control points are not always available.

In the second part of the experiment we investigate the impact of ETAD products on interferometric applications such as landslides and InSAR velocity retrieval. In this experiment, a series of ETAD products was used to simulate atmospheric phase screens that are then subtracted from S-1 interferograms. As test area the steep fjords and valleys in Norway that are severely prone to landslides, were selected. In this area NORCE, PPO.labs and the Geological Survey of Norway (NGU) operate a national ground motion service which will be supported by the upcoming European Ground Motion Service (EGMS) in the near future. In these regions atmospheric effects are in general visible in interferograms and hamper the deformation measurements when the atmospheric conditions change between SAR acquisitions. These tropospheric phase errors may introduce several fringes indicating a false motion and many data sets are required to reduce this error by InSAR time-series methods. Initial analysis has demonstrated that about 95% of the 66 produced atmospheric interferograms show clearly the atmospheric effects observed in the SAR interferograms. After subtraction of ETAD-based phase screens from the SAR interferograms, the stratification signal is significantly reduced and some of the large-scale trends are removed.

In the presentation we will explain the basis of the ETAD correction method, how to apply it for offset tracking and InSAR applications, and we will show results of both evaluation experiments.

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