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Maintenance of the National Realisation of ETRS89 in Sweden: re-analysis of 20-years GPS data for SWEREF stations

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The national geodetic reference frame of Sweden called SWEREF 99, was adopted in 2000 by EUREF as the realisation of ETRS89 in Sweden and was officially introduced in 2001 as a national reference frame, that eventually in 2007 replaced the former reference frame. The SWEREF 99 reference frame is defined by an active approach through the 21 fundamental SWEPOS permanent GNSS stations, hence relying on positioning services such as the network real time kinematic (NRTK) and post processing service. The SWEREF 99 coordinates are assumed to be fixed in time and no temporal variations are expected. However, the stability of the stations and their coordinates can be altered due to equipment change or software as well as local movements at the reference stations.

To be able to check all alterations mentioned above and having a backup national network of GNSS stations, approximately 300 passive so-called consolidation stations are used. The consolidation stations are a subset (main part) of the so-called SWEREF stations established from 1996 and onwards. All 300 stations are remeasured with static GNSS for 2x24 hours using choke ring antennas on a yearly basis with 50 stations each year. The original processing was done with the Bernese GNSS software (here called Bernese original) and the reprocessing was carried out with both the Bernese and the GAMIT-GLOBK software packages during 2017-2018.

The resulting coordinates in SWEREF 99 from GAMIT and Bernese processing are equal at $\sim$1.2 mm level for horizontal and 4 mm for vertical components (1 sigma) when using the same models and processing strategy. The original processing, which partly is based on other models and parameters, differs slightly more (rms 2.4 mm) for the north component. Our analysis both from Bernese and GAMIT shows that the standard uncertainties for a single SWEREF 99 determination (2x24 hrs) is $\sim$2 mm for the horizontal components and $\sim$6-7 mm in height. However, since some stations are slowly moving they have slightly increased the estimated uncertainties. It is interesting to note that the repeatability is on the same level also for the original processing, where we have differences in models and parameters used during the years. This indicates that the SWEREF-concept of determining SWEREF 99 coordinates has worked well on the mentioned uncertainty level.

We performed trend analysis and statistical tests to investigate the stability of the estimated SWEREF 99 coordinates. The analysed station time series (minimum three observations) showed that about 14% of the stations had significant trends at the 95%-level. The possible explanation for those trends can be either local deformation and/or residuals of uplift model and/or computational effects such as lack of good or enough close-by stations for Helmert transformations from ITRF to SWEREF 99.

The outcomes of the new processing and analysis reported here, are used to analyse the stability of SWEREF 99 after two decades. The results have also been used to define the SWEREF 99 component in the fit of the SWEN17_RH2000 new geoid model to SWEREF 99 and RH 2000 (Swedish realisation of EVRS).