Geodetic SAR for Height System Unification and Sea Level Research - Observation Concept and Results in the Baltic Sea

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Traditionally, sea level is observed at tide gauge stations, which usually also serve as height reference stations for national leveling networks and therefore define a height system of a country. Thus, sea level research across countries is closely linked to height system unification and needs to be regarded jointly. One of the main deficiencies to use tide gauge data for geodetic sea level research and height systems unification is that only a few stations are connected to permanent GNSS receivers next to the tide gauge in order to systematically observe vertical land motion. As a new observation technique, absolute positioning by SAR using active transponders on ground can fill this gap by systematically observing time series of geometric heights at tide gauge stations. By additionally knowing the tide gauge geoid heights in a global height reference frame, one can finally obtain absolute sea level heights at each tide gauge. With this information the impact of climate change on the sea level can be quantified in an absolute manner and height systems can be connected across the oceans.
The paper presents the results of a project, which was conducted in the years 2019 to 2021 in the frame of ESA´s Baltic+ initiative. Within this project a test network of electronic corner reflectors (ECR) as targets for Sentinel-1 was realized in the Baltic Sea area. The ECR locations were either co-located with tide gauges or with permanent GNSS stations in order to observe systematically the ellipsoidal heights of the tide gauges and possibly also any vertical land motion at the stations. Data for the year 2020 were collected at 10 stations in Estonia, Finland, Poland and Sweden and jointly analyzed with GNSS data, tide gauge records and regional geoid height estimates. The obtained results are promising, but also exhibit some problems related to the ECR´s and their performance. At co-located GNSS stations the estimated ellipsoidal heights agree in a range between about 2 and 50 cm between both observation systems. From the results it could be identified that most likely variable systematic electronic instrument delays of the ECR´s are the main reason for these

differences and that each instrument needs to be calibrated individually. Nevertheless, the project provides a valuable data set, which offers the possibility to enhance methods and procedures in order to develop the geodetic SAR positioning technique towards operability. All data and reports are accessible at the following web site: https://www.asg.ed.tum.de/iapg/baltic/