Climate change leads to a number of impacts that directly threaten human life and cause serious economic losses. Many of these are water-related, such as droughts and floods. The analyses in this project will be focused on terrestrial water storage (TWS), that is, water stored a.o. in rivers and plants, as ice or snow, and as a groundwater. TWS changes monitoring is therefore crucial to understand the dynamics of climate change, and is now possible by using the modern geodetic techniques, within the field of science known as hydrogeodesy. From 2002 to 2017, this was made possible by the Gravity Recovery and Climate Experiment (GRACE) mission, which provided observations of changes in the Earth's gravity field (changes in the distribution of masses, including water), affecting the real-time measured distance between a pair of satellites. After nearly a one-year gap, the GRACE Follow-On (near-identical hardware) have been continuing predecessor's tasks to this day. TWS changes from both missions have their drawbacks, low spatial (about 3°x3°) and temporal (1 month) resolutions, limiting their use to global/regional analyses and making it impossible to study dynamic variability of the hydrological cycle. Since the last decade, daily TWS changes have been determined by inverting displacement time series observed with Global Navigation Satellite Systems (GNSS) permanent stations, according to the theory of the Earth's crust elastic response – an increase (decrease) of water masses causes subsidence (uplift) of the stations. The aforementioned approach makes it possible to obtain TWS changes with higher spatial resolution compared to GRACE/-FO, but requires the availability of a sufficiently dense network of permanent stations. Researchers are performing GNSS integration with other techniques, such as GRACE/-FO or Interferometric Synthetic Aperture Radar (InSAR) to increase the number of observations and thus the spatial resolution of TWS changes. However, studies devoted to the inversion method commonly focus on vertical-only GNSS-observed displacements, ignoring horizontal displacements – the horizontal component is important, because the stations' motion towards the loading mass is three-dimensional. In addition, the most of studies concern vast areas with pronounced and well-known TWS changes, and Europe, which is increasingly experiencing prolonged droughts (a.o. causing economic losses) is commonly omitted. The main objective of this project is joint inversion of horizontal and vertical (3D) GPS (Global Positioning System)-observed displacements into TWS changes in Europe and estimation of differences by comparing to traditional vertical-only (1D) GPS-observed displacements inversion. Simulations will identify the likely mathematical benefits of additional use of horizontal displacements, and GPS-inverted TWS changes will be validated with high-resolution hydrological data. We expect that the obtained results will contribute to the further development of hydrogeodesy and will be a confirmation of the widespread use of satellite technology, mainly associated with navigation purposes.

Keywords: GPS, displacements, inversion, TWS, 1D, 3D