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Quality assessment of the gridded climate indices estimated from GNSS displacements for the European area

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For more than 30 years, the Global Navigation Satellite System (GNSS) has successfully detected local crust deformations. These changes in deformation are caused, among other things, by changes in Total Water Storage (TWS), which reflect regular changes in the water system, but are also coupled with changes resulting from unexpected climate change. Current water conflicts caused by climate variability, increased human activity, population growth and food demand are leading to an increased importance of monitoring the abundance of the terrestrial hydrosphere. Such monitoring is increasingly being carried out using GNSS observations, mainly due to the impressive number of permanent stations distributed on Earth. However, the distribution of GNSS stations is irregular, and the displacement time series is often incomplete. Moreover, because of systematic errors, consistency of several parameters estimated for nearby GNSS stations may be very low. To eliminate the impact of these errors, but still capture regular changes in the climate system, we estimated drought severity index (DSI) using GNSS displacement time series over Europe, and interpolated these station-based DSI values over European area in a 1 per 1 degree grid. The quality of interpolated GNSS-DSI values has been assessed using four external datasets: (1) the Gravity Recovery and Climate Experiment (GRACE) and GRACE Follow-On (GRACE-FO) data, (2) combination of GRACE/-FO data with the Satellite Laser Ranging (SLR) data, provided by the University of Bonn, (3) combination of SLR data and high-low Satellite-To-Satellite Tracking (hlSST) data, provided by Leibniz University Hannover, and (4) the self-calibrating Palmer Drought Severity Index (scPDSI). The external datasets have low spatial resolution, when compared to station-dependent GNSS-DSI and the scPDSI index is unable to capture several real water changes. Using GNSS displacements for estimated of DSI reduces these limitations. Our results show that GNSS-based DSI is spatially coherent with indicators derived from other datasets and is able to map dry and wet periods occurring over Europe. GNSS-DSI are also able to capture extreme short events not observed by other datasets. We note that the GRACE-DSI values show the least consistency with GNSS-DSI values. We find also that the DSI values estimated from combined GRACE and SLR indices have largest root-mean-square values for Europe. Our results show that GNSS displacements can be applied to study human and/or climate impact on water changes in small spatial and temporal scales, which may be averaged out in the other datasets; this hold the true especially in regions where GNSS stations are densely distributed.